Dominion Resources Services, Inc.
5000 Dominion Boulevard, Glen Allen, VA 23060

Web Address: www.dom.com

Dominion

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SEP 17 2015
DEQ - BRRO

September 16, 2015

BY: OVERNIGHT MAIL

Mr. David J. Brown
Air Permit Manager
Virginia Department of Environmental Quality
Blue Ridge Regional Office
7705 Timberlake Rd.
Lynchburg, VA 24502

RE: Buckingham Compressor Station
Article 6 New Source Permit Application

Dear Mr. Brown:

Atlantic Coast Pipeline, LLC proposes to construct and operate the Atlantic Coast Pipeline, an approximately 556-mile-long interstate natural gas transmission pipeline system designed to meet growing energy needs in Virginia and North Carolina. Enclosed is an application for a new natural gas compressor station to be located in Buckingham County, Virginia. The compressor station will include the following equipment:

- Solar Mars 100 Combustion Turbine;
- Solar Taurus 70 Combustion Turbine;
- Solar Taurus 60 Combustion Turbine;
- Solar Centaur 50L Combustion Turbine;
- Boiler rated at 9.5 MMBtu/hr;
- Four Line Heaters each rated at 17 MMBtu/hr;
- Ten Capstone C200 Microturbines, each rated at 200 kW ;
- Accumulator Tank with a capacity of 2,500 gallons;
- Hydrocarbon Waste Tank with a capacity of 2,000 gallons; and
- Aqueous Ammonia Storage Tank with a capacity of 8,000 gallons.

The application also includes various operational natural gas releases associated with station components and piping fugitive emissions related to equipment proposed at the Buckingham Compressor Station.

Should you have any questions or need additional information, please feel free to contact William Scarpinato at (804) 273-3019 or via email at william.a.scarpinato@dom.com.

Sincerely,

Robert M Bisha

Robert M. Bisha
Project Director, Atlantic Coast Pipeline
Dominion Environmental Services

Dominion Resources Services, Inc.
5000 Dominion Boulevard, Glen Allen, VA 23060

Web Address: www.dom.com

Dominion

RECEIVED
SEP 17 2015
DEQ - BRRO

September 16, 2015

BY: OVERNIGHT MAIL

Department of Environmental Quality
Receipts Control
P.O. Box 1104
Richmond, VA 23218

RE: Buckingham Compressor Station
Article 6 New Source Permit Application

Dear Madam or Sir:

Enclosed is the application fee form and check for $1,574 for a new natural gas compressor station to be located in Buckingham County, Virginia. The above referenced application was submitted September 16, 2015 to David J. Brown, Air Permit Manager, Blue Ridge Regional Office.

Should you have any questions or need additional information, please feel free to contact William Scarpinato at (804) 273-3019 or via email at william.a.scarpinato@dom.com.

Sincerely,

Robert M. Bisha

Robert M. Bisha
Project Director, Atlantic Coast Pipeline
Dominion Environmental Services

DA0375

Atlantic Coast Pipeline
C/O Dominion
P.O. BOX 25459
Richmond, VA 23260-5459

Atlantic Coast Pipeline

Date: 08/27/2015
Document #: 2000001402ACP1
Check #: 000114
Payment Amount: 1,574.00

000001 R3K2SDA
VIRGINIA COMMONWEALTH OF
TREASURER
PO BOX 1104
RICHMOND VA 23218

Remittance Advice

Vendor Number: 300125282

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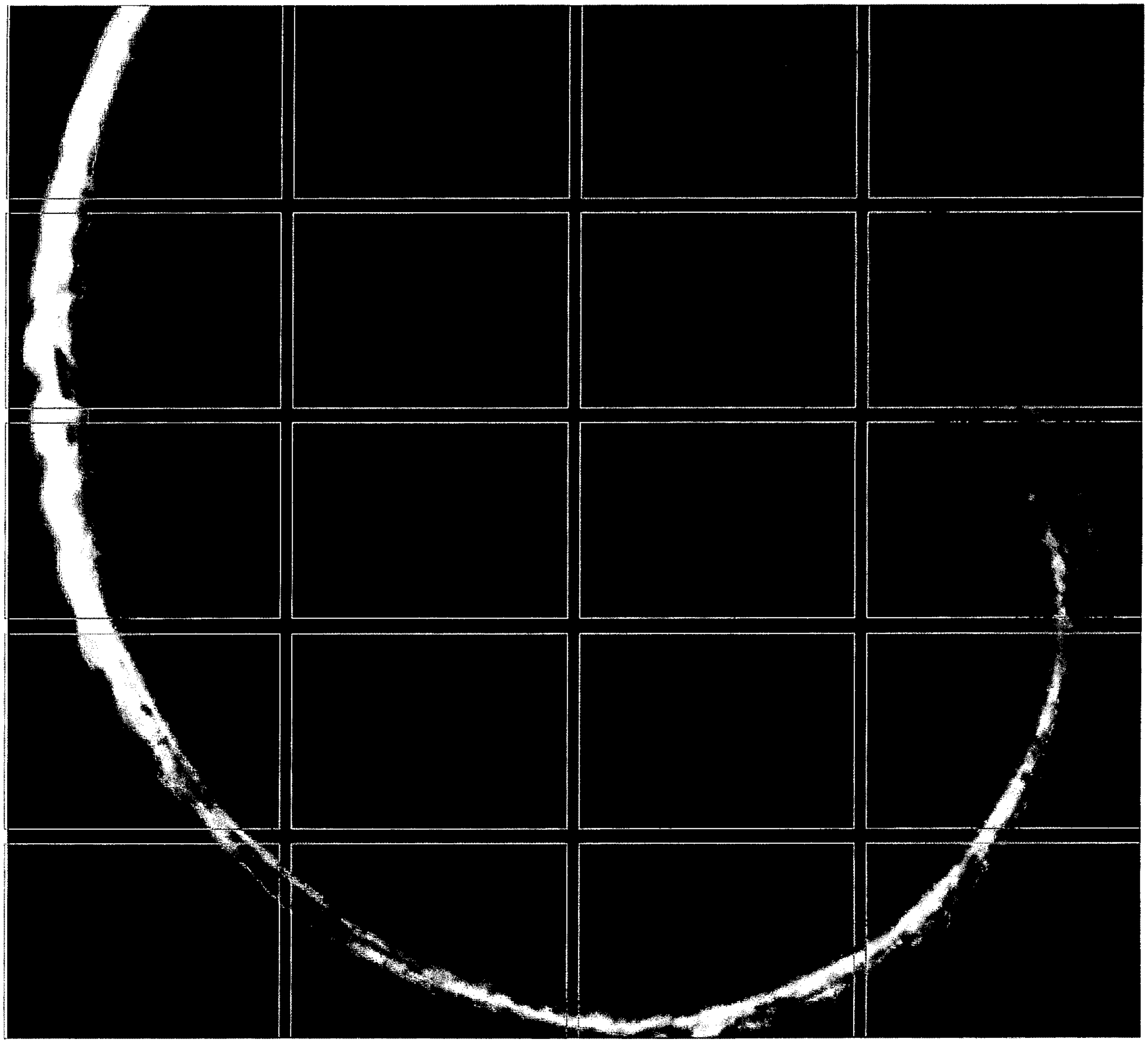
Invoice Date	Invoice #	Purchase Order	Invoice Gross Amt	Discount Amount	Invoice Net Amt
08/24/2015	EF0000070856		1,574.00	0.00	1,574.00
ACP-2 COMPRESSOR STATION AIR PERMIT APPLICATION FE					

PLEASE DETACH BEFORE DEPOSITING CHECK



Prepared For:

Atlantic Coast Pipeline, LLC.

Atlantic Coast Pipeline Project
Permit Application
Buckingham Compressor Station
Buckingham County, VA

September 2015

Environmental Resources Management
75 Valley Stream Parkway, Suite 200
Malvern, PA 19355

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1.0 INTRODUCTION

1.1 BACKGROUND

Atlantic Coast Pipeline, LLC (ACP, LLC) proposes to construct and operate the Atlantic Coast Pipeline (ACP), an approximately 556-mile-long interstate natural gas transmission pipeline system designed to meet growing energy needs in Virginia and North Carolina. The proposed project has the capacity to deliver 1.5 billion standard cubic feet of natural gas per day (bscf/d) from Pennsylvania and West Virginia to power generation facilities and other end-users.

In support of the ACP, Dominion Transmission Inc. (DTI), a subsidiary of Dominion, will contract with ACP, LLC to construct and operate the Buckingham Compressor Station (ACP-2) in Buckingham County, Virginia to provide compression to support the transmission of natural gas. An adjacent metering and regulating (M&R) station (Woods Corner) will also be operated by DTI and will therefore be considered part of the Buckingham Compressor Station.

1.2 APPLICATION OVERVIEW

ACP, LLC submits this Article 6 permit application to the Virginia Department of Environmental Quality (DEQ), Blue Ridge Regional Office for the authority to construct the Buckingham Compressor Station in Buckingham County, Virginia. This permit application narrative is provided to add clarification and/or further detail to the information in the permit application forms provided by the DEQ.

Concurrent with the submittal of this air quality permit application, other required environmental permits and approvals are being pursued with the appropriate regulatory agencies.

This section (Section 1) contains introductory information. Section 2 presents a description of the Buckingham Compressor Station and its associated equipment. The estimated emissions of regulated pollutants from the equipment and operating scenarios are presented in Section 3. Section 4 addresses federal regulatory requirements applicable to project sources and Section 5 provides a review of State regulatory requirements. Section 6 is the State Best Available Control Technology (BACT) analysis for the combustion turbines. Section 7 provides ACP, LLC's proposed compliance demonstration methods.

This application contains the following appendices:

- Appendix A – Virginia DEQ Form 7 Application Forms;

- Appendix B – Facility Plot Plan;
- Appendix C – Potential to Emit Calculations; and
- Appendix D – Vendor Specifications.

2.0 FACILITY AND PROJECT DESCRIPTION

2.1 BUCKINGHAM COMPRESSOR STATION

The Buckingham Compressor Station will operate in Buckingham County, Virginia to provide compression to support the transport of natural gas. The proposed project will require the construction of a new facility subject to the requirements of 9 VAC 5-80 - "*State Operating Permits*" and 9 VAC 5-85 - "*Permits for Stationary Sources of Pollutants Subject to Regulation*". In addition to the Buckingham Compressor Station, the facility will also include a nearby metering and regulating (M&R) station (Woods Corner) in Buckingham County, also operated by DTI.

ACP, LLC seeks authorization for the construction and operation of:

- One (1) Solar Mars 100 Combustion Turbine (CT-01);
- One (1) Solar Taurus 70 Combustion Turbine (CT-02);
- One (1) Solar Taurus 60 Combustion Turbine (CT-03);
- One (1) Solar Centaur 50L Combustion Turbine (CT-04);
- One (1) Boiler (WH-01) rated at 9.5 Million British Thermal Units per hour (MMBtu/hr);
- Four (4) ETI WB Line Heaters (LH-01, LH-02, LH-03, and LH-04) each rated at 17 Million British Thermal Units per hour (MMBtu/hr) (located at Woods Corner);
- Ten (10) Capstone C200 Microturbines (MT-01, MT-02, MT-03, MT-04, MT-05, MT-06, MT-07, MT-08, MT-09, and MT-10) each rated at 200 kW [268 hp];
- One (1) Accumulator Tank (TK-1) with a capacity of 2,500 gallons;
- One (1) Hydrocarbon Waste Tank (TK-2) with a capacity of 2,000 gallons;
- One (1) Aqueous Ammonia Storage Tank (TK-3) with a capacity of 8,000 gallons; and
- Various operational natural gas releases associated with station components (FUG-01) and piping fugitive emissions (FUG-02) related to the equipment proposed at the Buckingham Compressor Station.

A map displaying the location of the Buckingham Compressor Station is provided in Figure 2.1 of this application.

FIGURE 2.1 BUCKINGHAM COMPRESSOR STATION LOCATION MAP

2.2 AGGREGATION DETERMINATION

The Buckingham Compressor Station will be operated by Dominion Transmission Inc. Stationary sources of air pollutants may require aggregation of total emission levels if these sources share the same industrial grouping, are operating under common control, and are classified as contiguous or adjacent properties. DTI will operate the Buckingham Compressor Station with the same industrial grouping as the adjacent Woods Corner M&R station. This application includes emission sources associated with both the compressor station and the M&R station. Other than the interstate pipeline, which is specifically exempt from the requirement to aggregate as stated in the preamble to the 1980 PSD regulations, there are no other facilities that would be considered adjacent to the Buckingham Compressor Station and thus no other sources must be aggregated with the Buckingham Compressor Station.

3.0 *PROJECT EMISSIONS INFORMATION*

As discussed in Section 2.1 of this application, ACP, LLC seeks the authority to construct and operate new emission sources. This section provides a description of the basis for the estimation of emissions from these sources.

3.1 *COMBUSTION TURBINES*

The proposed natural gas-fired turbines to be installed at the Buckingham Compressor Station will be equipped with Solar's SoLoNOx dry low NO_x combustor technology as well as add-on emission controls including selective catalytic reduction (SCR) for NO_x and oxidation catalyst for CO and VOC.

Emissions for the Solar Turbines assume that the units will operate up to 8,760 hours per year and up to 100% rated output. Pre-control (SCR and oxidation catalyst) emissions of nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOC) are based on emission rates provided by Solar. VOC emissions are estimated as 10% of uncombusted hydrocarbon (UHC). Solar also provided emission estimates for UHC, carbon dioxide (CO_2), formaldehyde and total hazardous air pollutants.

The pre-control emission rates for normal operating conditions are as follows (all emissions rates are in terms of parts per million dry volume (ppmvd) @ 15% O_2):

- 9 ppmvd NO_x;
- 25 ppmvd CO;
- 25 ppmvd unburned hydrocarbons (UHC); and
- 2.5 ppmvd VOC.

The proposed SCR will further reduce the normal operation NO_x emission rate for each of the proposed turbines to 5 ppmvd at 15% O_2.

Per vendor estimates, the oxidation catalyst will provide 80% control for CO, to achieve 5 ppmvd CO @ 15% O_2 during normal operation. The catalyst will also control organic compound emissions and will provide an estimated 50% control for VOC and formaldehyde emissions.

Vendor estimates for SCR and oxidation catalyst performance are provided in Appendix B.

At very low load and cold temperature extremes, the turbine system must be controlled differently in order to assure stable operation. The required adjustments to the turbine controls at these conditions cause emissions of NO_x, CO and VOC to increase (emission rates of other pollutants are unchanged). Low-load operation (non-normal SoLoNOx operation) of the turbines is expected to occur only during periods of startup and shutdown. Solar has provided emissions estimates during start-up and shutdown (see Solar Product Information Letter (PIL) 170, included as part of the vendor attachments to this application for more detail).

Similarly, Solar has provided emissions estimates for low temperature operation (inlet combustion air temperature less than 0° F and greater than -20° F). Table 3.1 provides estimated pre-control emissions from the turbines at low temperature conditions.

TABLE 3.1 PRE-CONTROL TURBINE LOW TEMPERATURE EMISSION RATES (< 0° F AND > -20° F)[1]

Applicable Load	NOx, ppm	CO, ppm	UHC, ppm
50-100% load	120	150	50

1. *Emissions Estimates from Table 2 of Solar Product Information Letter 167.*

ACP, LLC reviewed historic meteorological data from the previous five years for the region to estimate a worst case number of hours per year under sub-zero (less than 0° F but greater than -20° F) conditions. The annual hours of operation during sub-zero conditions were conservatively assumed to be not more than 50 hours per year.

A summary of the controlled potential emissions of NO_X, CO, and VOC during normal operations and low temperature scenarios is provided in Table 3.2.

TABLE 3.2 TURBINE CONTROLLED SHORT-TERM EMISSION RATES

Pollutant	Operating Scenario	CT-01 Solar Mars 100 Turbine lb/hr	CT-02 Solar Taurus 70 Turbine lb/hr	CT-03 Solar Taurus 60 Turbine lb/hr	CT-04 Solar Centaur 50L Turbine lb/hr
NO_x	Normal	2.6	1.8	1.3	1.1
	Low Temp.	34.7	23.6	17.8	14.7
CO	Normal	1.6	1.1	0.8	0.7
	Low Temp.	9.5	6.4	4.8	4.0
VOC	Normal	0.2	0.2	0.1	0.1
	Low Temp.	0.4	0.3	0.23	0.2

The emission rates presented in Table 3.2 are estimates based on the emissions factors provided by Solar multiplied by the control efficiency expected from the installation of the SCR (approximately 44% NO_x control) and oxidation catalyst (approximately 50% VOC control and 80% CO control).

Potential turbine emissions also include a conservatively assumed uncontrolled potential emissions from start-up and shutdown events calculated using emission data provided by Solar. Although these emissions are provided as uncontrolled for the purposes of potential to emit estimations, ACP, LLC expects that some control may be achieved by the combustion turbine control devices during the start-up and shutdown events. Ton per year potential emission estimates are based on an assumed count of 100 start-up and 100 shutdown events per year. The duration of each start-up and shutdown is expected to be approximately 10 minutes per event. Thus, it is assumed that there will be approximately 33.3 hours of start-up and shutdown event time when the unit may not be operating in SoLoNOx mode. Table 3 of Solar PIL 170 was used as basis for emissions during these events.

A summary of the potential emissions during start-up and shutdown events is presented in Tables 3.3 and 3.4.

To practically track these events and associated emissions, ACP, LLC proposes to keep track of the total number of hours of non-SoLoNOx mode (a parameter monitored by the turbine control logic) and utilize an average start-up / shutdown emission rate (equivalent lb/hr based on 10 minutes per event). The proposed compliance demonstration is provided in Section 7 of this report.

TABLE 3.3 TURBINE POTENTIAL EMISSIONS DURING START-UP EVENTS

Pollutant	CT-01 Solar Mars 100 Turbine		CT-02 Solar Taurus 70 Turbine		CT-03 Solar Taurus 60 Turbine		CT-04 Solar Centaur 50L Turbine	
	lb/event	tpy	lb/event	tpy	lb/event	tpy	lb/event	tpy
NO_x	1.4	0.070	0.8	0.040	0.7	0.035	0.8	0.040
CO	123.5	6.18	73.1	3.66	64.3	3.22	69.1	3.46
VOC	1.42	0.071	0.84	0.042	0.74	0.037	0.80	0.040
CO_2	829	41.5	519	26.0	410	20.5	469	23.5
CH_4	5.68	0.284	3.36	0.168	2.96	0.148	3.20	0.160
CO_2e	971	48.6	603	30.2	484	24.2	549	27.5

TABLE 3.4 TURBINE POTENTIAL EMISSIONS DURING SHUTDOWN EVENTS

Pollutant	CT-01 Solar Mars 100 Turbine		CT-02 Solar Taurus 70 Turbine		CT-03 Solar Taurus 60 Turbine		CT-04 Solar Centaur 50L Turbine	
	lb/event	tpy	lb/event	tpy	lb/event	tpy	lb/event	tpy
NO_x	1.7	0.085	1.1	0.055	0.4	0.020	0.4	0.020
CO	149.2	7.46	93.4	4.67	33.0	1.65	35.4	1.77
VOC	1.70	0.085	1.06	0.053	0.380	0.019	0.400	0.020
CO_2	920	46.0	575	28.8	204	10.2	217	10.9
CH_4	6.80	0.340	4.24	0.212	1.52	0.076	1.60	0.080
CO_2e	1,090	54.5	681	34.1	242	12.1	257	12.9

Table 3.5 includes the facility's potential emissions for the combustion turbines including normal continuous operation controlled by SoLoNOx mode, SCR, and oxidation catalyst, low temperature operation controlled by the SCR and oxidation catalyst as well, as the uncontrolled emissions associated with start-up and shutdown events.

TABLE 3.5 TURBINE POTENTIAL EMISSIONS

Pollutant	CT-01 Solar Mars 100 Turbine tpy	CT-02 Solar Taurus 70 Turbine tpy	CT-03 Solar Taurus 60 Turbine tpy	CT-04 Solar Centaur 50L Turbine tpy
NO_x	12.3	8.4	6.3	5.2
CO	20.7	13.1	8.5	8.2
VOC	1.1	0.8	0.6	0.5
SO_2	2.1	1.4	1.1	0.9
PM_{-Filt}	3.6	2.4	1.8	1.5
$PM_{10-Filt}$	3.6	2.4	1.8	1.5
$PM_{2.5-Filt}$	3.6	2.4	1.8	1.5
PM_{-Cond}	8.9	6.0	4.5	3.7
CO_2	74,385	50,035	37,843	31,329
CH_4	6.0	4.0	3.0	2.5
N_2O	1.9	1.3	1.0	0.8
CO_2e	75,094	50,511	38,201	31,967
NH_3	8.1	5.8	4.3	3.6
Total HAP	0.8	0.5	0.4	0.4
Formaldehyde	0.7	0.5	0.34	0.3

3.2 *BOILER AND HEATERS*

The proposed natural gas boiler will be used to provide building heat (space heating) only, and will have a maximum heat input capacity of 9.5 MMBtu/hr. The boiler will use Low NO_x Burners (LNB). Emissions for the proposed natural gas-fired Boiler are calculated using EPA's AP-42 emission factors for Natural Gas Combustion (Section 1.4) conservatively assuming 8,760 hours per year.

Emissions for the four (4) proposed 17.0 MMBtu/hr ETI Line Heaters at the Woods Corner M&R station conservatively assume 8,760 hours of operation per year and are calculated using vendor provided emissions factors for NO_x, CO, VOC, and PM. All other pollutants were calculated using EPA's AP-42 emission factors for Natural Gas Combustion (Section 1.4).

Under 9 VAC 5-80-1105, external combustion units using gaseous fuel with a maximum heat input of less than 50 MMBtu/hr are exempt from permitting requirements. For completeness of the project, the potential emissions from the boiler and line heaters are provided in Table 3.6. The line heater emissions are presented on a per unit basis.

TABLE 3.6 *BOILER AND HEATER POTENTIAL*

Pollutant	WH-01 Boiler tpy	LH-01 thru LH-04 Line Heater tpy
NO_x	2.04	0.819
CO	3.43	2.76
VOC	0.224	0.447
SO_2	0.024	0.044
$PM_{\text{-Filt}}$	0.078	0.105
$PM_{10\text{-Filt}}$	0.078	0.105
$PM_{2.5\text{-Filt}}$	0.078	0.105
$PM_{\text{-Cond}}$	0.233	0.416
CO_2	4,895	8,760
CH_4	0.094	0.168
N_2O	0.090	0.161
CO_2e	4,924	8,812
Total HAP	0.077	0.138
Formaldehyde	0.003	0.005
Hexane	0.074	0.131

3.3 *CAPSTONE MICROTURBINES*

Emission estimates for the Capstone Microturbines assume 8,760 hours per year at 100% rated output. The microturbines will provide the electrical power to operate the compressor station and M&R station. These microturbines each have a rated heat input of 2.28 MMBtu/hr and will fire natural gas. Emissions of NO_x, CO, VOC, CO_2 and CH_4 are based on emission rates from manufacturer's data. These vendor specifications are included in Appendix D. All other pollutant emissions are based on Section 3.1 of EPA's AP-42 emission factors for natural gas-fired combustion turbines.

The potential emissions (on a per unit basis) for the new Capstone Microturbines are provided in Table 3.7.

TABLE 3.7 MICROTURBINE POTENTIAL EMISSIONS

Pollutant	**MT-01 thru MT-10 Capstone C200 Microturbine tpy**
NO_x	0.403
CO	1.10
VOC	0.088
SO_2	0.010
$PM_{\text{-Filt}}$	0.006
$PM_{10\text{-Filt}}$	0.006
$PM_{2.5\text{-Filt}}$	0.006
$PM_{\text{-Cond}}$	0.014
CO_2	1,332
CH_4	0.088
N_2O	0.009
CO_2e	1,336
Total HAP	0.003
Formaldehyde	0.000

3.4 *FUGITIVE EMISSIONS*

The proposed project will include fugitive components including valves, flanges, pumps, etc. Emission factors for fugitive components were based on EPA's report on equipment leaks for oil and gas production facilities[i]. It is

[i] USEPA, 1995. "Emission factors from Protocol for Equipment Leak Emission Estimates," EPA-453/R-95-017 Table 2.4, Oil and Gas Production Operations Average Emission Factors.

expected that this facility will comply with recently proposed New Source Performance Standard Subpart OOOOa which incorporates leak detection monitoring. However, no credit for any reduced emissions has been taken in the numbers below.

Additionally, ACP, LLC has estimated emissions from blowdown events. ACP, LLC will minimize these events whenever possible, but blowdown of the machines and piping will sometimes occur for safety reasons and to ensure protection of equipment. ACP, LLC has also conservatively included estimated emissions from one site-wide blowdown event in these emission calculations. Such events are not routine, but typically occur once every five years.

The total fugitive emissions are summarized in Table 3.8.

TABLE 3.8 POTENTIAL EMISSIONS ASSOCIATED WITH FUGITIVE COMPONENTS

Pollutant	FUG-01 Fugitive Leaks - Blowdowns tpy	FUG-02 Fugitive Leaks - Piping tpy
VOC	24.7	26.7
CO_2	25.6	27.6
CH_4	844	909
CO_2e	21,124	22,764
Total HAP	1.40	1.50

3.5 STORAGE TANKS

The Buckingham Compressor Station will operate three (3) aboveground storage tanks (ASTs). TK-1 (Accumulator Storage Tank) will have a capacity of 2,500 gallons and will receive and store pipeline liquids captured by the station's separators and filter-separators. The emissions associated with the operation of this accumulator storage tank are estimated using E&P Tanks to ensure capture of any flash emissions (which the EPA TANKS program cannot estimate). ACP, LLC has estimated that this storage tank will complete five (5) turnovers per year.

TK-2 (Hydrocarbon Waste Tank) will have a capacity of 2,000 gallons and will receive liquids from the compressor building and auxiliary building floor drains. The emissions associated with the operation of this hydrocarbon waste tank were calculated using EPA's TANKS program. ACP, LLC has estimated that this storage tank will complete five (5) turnovers per year.

The potential VOC emissions associated with the proposed new storage tanks, TK-1 and TK-2, are 0.35 tpy (0.08 lb/hr). Detailed emission calculations are provided in Appendix C of this document.

TK-3 (Aqueous Ammonia Storage Tank) will have a capacity of 8,000 gallons and will be used to supply aqueous ammonia to SCRs.

3.6 *PROJECT EMISSIONS*

The potential emissions associated with the proposed new equipment at the Buckingham Compressor Station are summarized in Table 3.9 in tons per year. Detailed emission calculations are provided in Appendix C of this document.

TABLE 3.9 FACILITY-WIDE POTENTIAL EMISSIONS (TPY)

	Criteria Pollutants								Greenhouse Gases					
Unit ID	NO_x	CO	VOC	SO_2	$PM_{\text{-Filt}}$	$PM_{10\text{-Filt}}$	$PM_{2.5\text{-Filt}}$	$PM_{\text{-Cond}}$	CO_2	CH_4	N_2O	CO_2e	NH_3	Total HAPs
CT-01	12.3	20.7	1.14	2.12	3.60	3.60	3.60	8.90	74,385	6.00	1.87	75,094	8.12	0.785
CT-02	8.35	13.1	0.775	1.43	2.42	2.42	2.42	5.99	50,035	4.00	1.26	50,511	5.77	0.525
CT-03	6.28	8.46	0.561	1.08	1.83	1.83	1.83	4.53	37,843	2.96	0.954	38,201	4.29	0.410
CT-04	5.20	8.19	0.477	0.894	1.51	1.51	1.51	3.74	31,329	2.52	0.788	31,627	3.58	0.352
WH-01	2.04	3.43	0.224	0.024	0.078	0.078	0.078	0.233	4,895	0.094	0.090	4,924	0.000	0.077
LH-01	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.000	0.138
LH-02	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.000	0.138
LH-03	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.000	0.138
LH-04	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.000	0.138
MT-01	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-02	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-03	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-04	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-05	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-06	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-07	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-08	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-09	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
MT-10	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.000	0.000
FUG-01	-	-	24.7	-	-	-	-	-	25.6	844		21,124	-	1.40
FUG-02	-	-	26.7	-	-	-	-	-	27.6	909	-	22,764	-	1.50
TK-1	-	-	0.350	-	-	-	-	-	-	-	-	-	-	-
TK-2	-	-	0.000	-	-	-	-	-	-	-	-	-	-	-
Total	41.5	75.8	57.6	5.83	9.92	9.92	9.92	25.2	246,897	1,770	5.70	292,856	21.8	5.63

mechanical drive" turbines must meet a NO_x limitation of 100 ppmv at 15 percent O_2 under the requirements of Subpart KKKK and units must minimize emissions consistent with good air pollution control practices during startup, shutdown and malfunction.

Solar provides an emissions guarantee of 9 parts per million volume dry (ppmvd) NO_x at 15 percent O_2 for the proposed SoLoNO$_x$ equipped units. These guarantees apply at all times except during periods of start-up and shutdown and periods with ambient temperatures below 0°F. In addition, SCR will be installed to lower emissions for all turbines to further reduce NO_x emissions to 5 ppmvd at 15 % O_2, except during periods of start-up and shutdown and periods with ambient temperatures below 0°F.

ACP, LLC plans to conduct stack tests for NO_x emissions to demonstrate compliance with the Subpart KKKK emissions limits.

The NSPS Subpart KKKK emission standard for SO_2 is the same for all turbines, regardless of size and fuel type. All new turbines are required to meet an emission limit of 110 nanogram per joule (ng/J) (0.90 pounds [lbs]/megawatt-hr) or a sulfur limit for the fuel combusted of 0.06 lbs/MMBtu. The utilization of natural gas as fuel ensures compliance with the SO_2 standard due to the low sulfur content of natural gas.

4.1.4 *40 CFR 60 Subparts OOOO and OOOOa – Standards of Performance for Crude Oil and Natural Gas Production, Transmission and Distribution*

Subpart OOOO currently applies to affected facilities that commenced construction, reconstruction, or modification after August 23, 2011. Subpart OOOO establishes emissions standards and compliance schedules for the control of VOCs and SO_2 emissions for affected facilities producing, transmitting, or distributing natural gas. Compressors located between the wellhead and the point of custody transfer to the natural gas transmission and storage segment are subject to this Subpart. Custody transfer is defined as the transfer of natural gas after processing and/or treatment in the producing operations. All compressor stations will be located after the point of custody transfer, and therefore centrifugal compressors driven by the proposed turbines are not currently subject to this regulation. Storage vessels located in the natural gas transmission and storage segment that have the potential for VOC emissions equal to or greater than 6 tpy are also subject to this Subpart. All storage vessels to be located at compressor stations will emit less than this threshold, and thus will not be subject to this regulation.

On August 18, 2015, EPA proposed amendments to 40 CFR 60, Subpart OOOO and proposed an entirely new Subpart OOOOa. If finalized, revisions proposed for Subpart OOOO would apply to oil and natural gas production, transmission, and distribution affected facilities that were constructed, reconstructed, and

4.0 FEDERAL REGULATORY REQUIREMENTS

4.1 NEW SOURCE PERFORMANCE STANDARDS (NSPS)

NSPS have been established by the EPA to limit air pollutant emissions from certain categories of new and modified stationary sources. The NSPS regulations are contained in 40 CFR Part 60 and cover many different source categories, and applicable categories are described below.

4.1.1 40 CFR 60 Subpart Dc - Standards of Performance for Small Industrial-Commercial-Institutional Steam Generating Units

Subpart Dc applies to steam generating units for which construction, modification, or reconstruction is commenced after June 9, 1989 and that have a maximum design heat capacity of 100 MMBtu/hr or less, but greater than or equal to 10 MMBtu/hr. The equipment subject to this regulation includes the four line heaters proposed to be installed. To demonstrate compliance with this rule, these sites will maintain and report fuel records certifying the fuel is in compliance with the NSPS Dc standards for SO_2.

4.1.2 40 CFR 60 Subpart Kb - Standards of Performance for Volatile Organic Liquid Storage Vessels

This regulation applies to volatile organic liquid storage vessels with storage capacities greater than or equal to 75 cubic meters (19,812 gallons) for which construction, reconstruction, or modification commenced after July 23, 1984. There are no petroleum storage vessels with capacities greater than 19,812 gallons planned at the Buckingham Compressor Station, and this regulation is therefore not applicable to the facility.

4.1.3 40 CFR 60 Subpart KKKK - Standards of Performance for Stationary Combustion Turbines

NSPS 40 CFR Part 60 Subpart KKKK regulates stationary combustion turbines with a heat input rating of 10 MMBtu/hr or greater that commence construction, modification, or reconstruction after February 18, 2005. Subpart KKKK limits emissions of NO_x as well as the sulfur content of fuel that is combusted from subject units.

The proposed Solar combustion turbines will be subject to the requirements of this subpart. Subpart KKKK specifies several subcategories of turbines, each with different NO_x emissions limitations. The proposed turbines fall within the "medium sized" (> 50MMBtu/hr, < 850 MMBtu/hr) category for natural gas turbines. "Medium sized" turbines must meet a NO_x limitation of 25 parts per million by volume (ppmv) at 15 percent oxygen (O_2), and "small sized, modified between August 23, 2011 and the Federal Register publication date (anticipated September 2015). Conversely, if finalized, Subpart OOOOa will apply to oil and natural gas production, transmission, and distribution affected facilities that are constructed, reconstructed, and modified after the Federal Register date. The proposed NSPS Subpart OOOOa would establish standards for both VOC and methane.

Based on the expected date of publication in the Federal Register, it is anticipated this project will be required to comply with the requirements of NSPS Subpart OOOOa. There is uncertainty if Subpart OOOOa will become final or what the final requirements will specifically include; however, the proposal contains provisions that would affect additional sources at the proposed facilities beyond Subpart OOOO. While storage tanks remain covered, Subpart OOOOa also includes provisions intended to reduce emissions from centrifugal compressors and equipment leaks from transmission and storage facilities. For centrifugal compressors, Subpart OOOOa proposes the use of dry seals or the control of emissions if wet seals are used. Dry seals are already planned for use in all proposed compressors. For equipment leaks, Subpart OOOOa proposes requiring periodic surveys using optical gas imaging (OGI) technology and subsequent repair of any identified leaks. The project will comply with all applicable leak detection provisions of proposed Subpart OOOOa.

4.2 *NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP)*

NESHAP regulations established in 40 CFR Part 61 and Part 63 regulate emission of air toxics. NESHAP standards primarily apply to major sources of Hazardous Air Pollutants (HAPs), though some Subparts of Part 63 have been revised to include area (non-major) sources. The NESHAP regulations under 40 CFR Part 61 establish emission standards on the pollutant basis whereas 40 CFR Part 63 establishes the standards on a source category basis. The Buckingham Compressor Station will not emit any single HAP in excess of 10 tpy and will not emit combined HAPS in excess of 25 tpy, and will therefore be designated as an area source of HAPs.

4.2.1 *40 CFR 63 Subpart HHH – National Emissions Standards for Hazardous Air Pollutants from Natural Gas Transmission and Storage Facilities*

This regulation applies to certain affected facilities at major HAP sources. The Buckingham Compressor Station will be an area HAP source. Therefore, this regulation is not applicable.

4.2.2 *40 CFR 63 Subpart DDDDD – National Emission Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers And Process Heaters*

Industrial, commercial, or institutional boilers or process heaters located at a major source of HAPs are subject to this Subpart. The Buckingham Compressor Station will not be a major source of HAPs, and therefore will not be subject to this Subpart.

4.2.3 *40 CFR 63 Subpart JJJJJJ – National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources*

This Subpart applies to area sources of HAPs. The Buckingham Compressor Station will be an area source of HAPs; however, gas-fired boilers as defined by this Subpart are not subject to any requirements under this rule. Furthermore, natural gas-fired process heaters are not subject to the 40 CFR 63 Subpart JJJJJJ. As such, this subpart does not apply.

4.2.4 *40 CFR 63 Subpart YYYY – National Emissions Standards for Hazardous Air Pollutants for Stationary Combustion Turbines*

Stationary combustion turbines located at major sources of HAP emissions are subject to this Subpart. The Buckingham Compressor Station will be an area HAP source. Therefore, this regulation is not applicable.

4.3 *PREVENTION OF SIGNIFICANT DETERIORATION (PSD) AND NON-ATTAINMENT NEW SOURCE REVIEW*

The air quality regulations for the Commonwealth of Virginia are codified in Title 9 of the Virginia Administrative Code (9 VAC) Agency 5, State Air Pollution Control Board. The Virginia State Regulations address federal regulations where Virginia has been delegated authority of enforcement, including Prevention of Significant Deterioration permitting.

The Buckingham Compressor Station will be located in Buckingham County. The air quality of Buckingham County is designated by the U.S. EPA as either "better than normal standards" or "unclassified/attainment" for all criteria pollutants (40 CFR 81.318). As such, new construction or modifications that result in emission increases are potentially subject to the PSD permitting regulations.

PSD applicability depends on the existing status of a facility (i.e. major or minor source) and the net emissions increase associated with the project. The major source threshold for PSD applicability for a new facility is 250 tons per year (tpy) unless the source is included on a list of 28 specifically defined industrial source categories for which the PSD "major" source threshold is 100 tpy. Since the

Buckingham Compressor Station is not one of the 28 listed sources, the PSD major source threshold is 250 tpy of any pollutant regulated by the Clean Air Act (CAA). Potential emissions of each criteria pollutant from the proposed facility will not exceed 250 tpy, as shown in Section 3. Therefore, the facility and project are not subject to PSD review.

4.4 *TITLE V OPERATING PERMIT*

See Section 5.0 for Title V applicability information.

4.5 *MAINTENANCE EMISSIONS AND FEDERAL ROUTINE MAINTENANCE, REPAIR AND REPLACEMENT PROVISIONS (RMRR)*

As part of normal operations of the Buckingham Compressor Station, ACP, LLC will routinely conduct activities associated with maintenance and repair of the facility equipment. These maintenance and repair activities will include, but will not be limited to, compressor engine startup/shutdowns, calibrating equipment, changing orifice plates, deadweight testing, changing equipment filters (e.g., oil filters, separator filters), compressor engine and auxiliary equipment inspection and testing, and use of portable gas/diesel engines for air compressors and lube guns.

Furthermore, in order to ensure the reliability of natural gas deliveries to their customers, ACP, LLC may conduct equipment and component replacement activities that conform to the currently applicable federal laws and regulations.

4.6 *CHEMICAL ACCIDENT PREVENTION AND RISK MANAGEMENT PROGRAMS (RMP)*

The Buckingham Compressor Station will not be subject to the Chemical Accident Prevention Provisions (40 CFR 68.1), as no chemicals subject to regulation under this Subpart will be present onsite. The aqueous ammonia stored will have a concentration of less than 20%.

4.7 *ACID RAIN REGULATIONS*

The Buckingham Compressor Station will not sell electricity and is a non-utility facility. Therefore, the facility will not be subject to the federal acid rain regulations found at 40 CFR Parts 72 through 77.

4.8 STRATOSPHERIC OZONE PROTECTION REGULATIONS

Subpart F, Recycling and Emissions Reductions, of 40 CFR Part 82, Protection of Stratospheric Ozone, generally requires that all repairs, service, and disposal of appliances containing Class I or Class II ozone depleting substances be conducted by properly certified technicians. The facility will comply with this regulation as applicable.

4.9 GREENHOUSE GAS REPORTING

On November 8, 2010, the USEPA finalized GHG reporting requirements under 40 CFR Part 98. Subpart W of 40 CFR Part 98 requires petroleum and natural gas facilities with actual annual GHG emissions equal to or greater than 25,000 metric tons CO_2e to report GHG from various processes within the facility. Following this project, ACP Station 2 is expected to be subject to GHG emissions reporting. If the emissions threshold is met or exceeded, ACP, LLC will comply with the applicable GHG reporting requirements.

5.0 STATE REGULATORY APPLICABILITY

This section outlines the State air quality regulations that could be reasonably expected to apply to the Buckingham Compressor Station and makes an applicability determination for each regulation based on activities planned at the Station and the emissions of regulated air pollutants associated with this project. This review is presented to supplement and/or add clarification to the information provided in the Virginia DEQ Article 6 permit application forms (Form 7).

The air quality regulations for the Commonwealth of Virginia are codified in Title 9 of the Virginia Administrative Code (9 VAC) Agency 5, State Air Pollution Control Board. The Virginia State Regulations address federal regulations where Virginia has been delegated authority of enforcement, including Prevention of Significant Deterioration permitting, Title V permitting, New Source Performance Standards (NSPS), and National Emission Standards for Hazardous Air Pollutants (NESHAP). These regulatory requirements in reference to the Buckingham Compressor Station are described in Table 5.1 below.

TABLE 5.1 STATE REGULATORY APPLICABILITY

Regulatory Citation	Applicable Requirement	Compliance Approach
General Provisions on Air Pollution Control (9 VAC 5-20)	The Air Pollution Control Board may require an owner of a stationary source to submit a control program, in a form and manner satisfactory to the board, showing how compliance is achieved.	For cases of equipment maintenance or malfunctions, a facility record and notification of instances to the board are required and will be submitted if any malfunctions occur.
Ambient Air Quality Standards (9 VAC 5-30)	Ambient air quality standards are required to assure that ambient concentrations of air pollutants are consistent with established criteria and shall serve as the basis for effective and reasonable management of the air resources.	The project will comply with the National Ambient Air Quality Standards.
Federal Operating Permits (9 VAC-5-80-50)	A federal operating permit is required for any major source or an area source subject a standard, limitation, or other requirement under Sections 111-112 of the Clean Air Act, unless otherwise exempt.	Because the site is below the Title V major source emissions thresholds and is not subject to a Title V by rule through a Federal standard, the Buckingham Compressor Station is not subject to this rule.
BACT (9 VAC 5-50-260 B)	Virginia's regulations establish that a BACT review must be completed for certain sources that are not otherwise exempt and whose total emissions exceed Uncontrolled Emission Rate (UER) thresholds	Subject emissions have been reviewed and have been demonstrated to meet BACT levels. See Section 6 for a full discussion.

Regulatory Citation	Applicable Requirement	Compliance Approach
State Operating Permits (9 VAC 5-80-800)	Virginia's SOPs are most often used by stationary sources to establish federally enforceable limits on potential emissions to avoid major NSR permitting (PSD and Non-Attainment permits), Title V permitting, and/or major source Maximum Achievable Control Technology (MACT) applicability. When a source chooses to use a SOP to limit their emissions below major source permitting thresholds, it is commonly referred to as a "synthetic minor" source. SOPs can also be used to combine multiple permits from a stationary source into one permit or to implement emissions trading requirements.	When a source chooses to use a SOP to limit their emissions below major source permitting thresholds, it is commonly referred to as a "synthetic minor" source. SOPs can also be used to combine multiple permits from a stationary source into one permit or to implement emissions trading requirements. The Buckingham Compressor Station will not seek a synthetic minor and is not subject to this regulation.
Construction Permits (9 VAC 5-80-1100)	Article 6 permitting must be completed before construction of a new source.	The required Form 7 application forms and attachments are included with this text report to satisfy this requirement for the construction of sources at the Buckingham Compressor Station.
Permits for Stationary Sources of Pollutants (9 VAC 5-85)	This chapter contains definitions and general provisions which are essentially identical to those discussed in 9 VAC-5-20.	See 9 VAC 5-20.
Emergency Generator Requirements (9 VAC 5-540)	Affected units are required to install a non-resettable hour metering device to monitor the operating hours for each unit, calculated monthly as the sum of each consecutive 12-month period. The non-resettable hour metering shall be observed by the owner or operator within a frequency no less than once per month. The owner or operator shall keep a log of the following; monthly observations of meters, start-up dates, equipment malfunctions, corrective actions, and shutdown dates. Records must be kept onsite for 5 years.	There are no proposed emergency generators at ACP 2, thus, 9 VAC 5-540 is not applicable to the Buckingham Compressor Station.

6.0 *BEST AVAILABLE CONTROL TECHNOLOGY REVIEW*

Consistent with Virginia's June 12, 2015 memo (APG-354; Permitting and BACT Applicability under Chapter 80 Article 6), ACP, LLC has reviewed the proposed sources to determine applicability of BACT review.

Per 9 VAC 5-80-1005C, new stationary sources with uncontrolled emission rates less than all of the emission rates specified (see Table 6.1 below) shall be exempt from the provisions of Article 6. The uncontrolled emission rate of a new stationary source is the sum of the uncontrolled emission rates of the individual affected emission units. Facilities exempted by subsection B of 9 VAC 5-80-1005 shall not be included in the summation of uncontrolled emissions for purposes of exempting new stationary sources.

Step 1 - Emission Units

ACP, LLC seeks the authority to construct and operate several new emission sources, as discussed in Section 2.1 of this application.

Step 2 - Individually Exempt Equipment

The emission units exempted under 9 VAC 5-80-1105B are listed below:

- One (1) Boiler (WH-01) rated at 9.5 Million British Thermal Units per hour (MMBtu/hr) - exempt as an external combustion source < 50 MMBtu/hr);
- Four (4) ETI WB Line Heaters (LH-01, LH-02, LH-03, and LH-04) each rated at 17 Million British Thermal Units per hour (MMBtu/hr) (located at Woods Corner) - exempt as an external combustion source < 50 MMBtu/hr);
- Ten (10) Capstone C200 Microturbines (MT-01, MT-02, MT-03, MT-04, MT-05, MT-06, MT-07, MT-08, MT-09, and MT-10) each rated at 200 kW - exempt as a turbine < 10 MMBtu/hr.

Step 3 - Annual UER Increase

The Uncontrolled Emission Rate (UER) for each new stationary source is summarized in Table 6.1 below:

TABLE 6.1 STATE EXEMPTION RATES OF REGULATED POLLUTANTS FOR NEW STATIONARY SOURCES (9 VAC 5-80-1105C.1) VS. UER

Pollutant	Exemption Levels	UER	Solar Mars 100 Turbine (tpy)	Solar Taurus 70 Turbine (tpy)	Solar Taurus 60 Turbine (tpy)	Solar Centaur 50L Turbine (tpy)	Fugitive Leaks - Blowdowns (tpy)	Fugitive Leaks - Piping (tpy)
CO	100 tpy	124	49.1	32.1	22.8	20.0	-	-
NO_x	40 tpy	57.5	22.0	15.0	11.3	9.3	-	-
SO_x	40 tpy	5.5	2.1	1.4	1.1	0.9	-	-
PM_F	25 tpy	9.4	3.6	2.4	1.8	1.5	-	-
PM_{10}	15 tpy	32.5	12.5	8.4	6.4	5.3	-	-
$PM_{2.5}$	10 tpy	32.5	12.5	8.4	6.4	5.3	-	-
VOC	25 tpy	56.9	2.1	1.5	1.1	0.9	24.7	26.7
Pb	0.6 tpy	-	-	-	-	-	-	-
Fluorides	3 tpy	-	-	-	-	-	-	-
Sulfuric Acid Mist	6 tpy	-	-	-	-	-	-	-
Hydrogen Sulfide (H_2S)	9 tpy	-	-	-	-	-	-	-
Total Reduced Sulfur (including H_2S)	9 tpy	-	-	-	-	-	-	-

Step 4 -UER Increases vs. Exempt Emission Rates

The total UER for PM_{10}, $PM_{2.5}$, NO_x, CO, and VOC exceed the threshold values in Table 6.1 and thus, are subject to BACT review. The results of the BACT review are provided below.

6.1 *BACT FOR PARTICULATE MATTER (PM_{10} AND $PM_{2.5}$)*

Particulate matter emissions result from the proposed combustion turbines.

The following summarizes the BACT evaluation conducted for the Solar combustion turbines, the only significant equipment type for the Buckingham Compressor Station with respect to PM_{10} and $PM_{2.5}$ emissions.

The emissions of particulate matter emissions from gaseous fuel combustion have been estimated to be less than 1 micron in equivalent aerodynamic diameter, have filterable and condensable fractions, and usually consist of hydrocarbons of larger molecular weight that are not fully combusted[ii]. Because the particulate matter typically is less than 2.5 microns in diameter, this BACT discussion assumes the control technologies for PM_{10} and $PM_{2.5}$ are the same.

As part of the step 1 analysis, searches of the RACT/BACT/LAER Clearinghouse (RBLC) database for similar units were conducted. For any instances where the emission rate is lower than what is proposed by ACP, LLC, comments have been provided detailing why the listed rate was not considered to be BACT.

Step 1 - Identify Potential Control Technologies

Pre-Combustion Control Technologies

The major sources of PM_{10} and $PM_{2.5}$ emissions from the gaseous fuel-fired combustion turbines are:

- The conversion of any fuel sulfur to sulfates and ammonium sulfates;
- Unburned hydrocarbons that can lead to the formation of PM in the exhaust stack; and
- PM in the ambient air entering the combustion turbines through their inlet air filtration systems, and the aqueous ammonia dilution air.

[ii] *USEPA, 2006 http://www.epa.gov/ttnchie1/conference/ei15/training/pm_training.pdf*

The use of clean-burning, low-sulfur gaseous fuels will result in minimal formation of PM_{10} and $PM_{2.5}$ during combustion. Good combustion practices will ensure proper air/fuel mixing ratios to achieve complete combustion, minimizing emissions of unburned hydrocarbons that can lead to the formation of PM emissions. In addition to good combustion practices, the use of high-efficiency filtration on the inlet air and SCR dilution air systems will minimize the entrainment of PM into the combustion turbine exhaust streams.

Post-Combustion Control Technologies

There are several post-combustion PM control systems potentially feasible to reduce PM_{10} and $PM_{2.5}$ emissions from the combustion turbine including:

- Cyclones/centrifugal collectors;
- Fabric filters/baghouses;
- Electrostatic precipitators (ESPs); and
- Scrubbers.

Cyclones/centrifugal collectors are generally used in industrial applications to control large diameter particles (>10 microns). Cyclones impart a centrifugal force on the gas stream, which directs entrained particles outward. Upon contact with an outer wall, the particles slide down the cyclone wall, and are collected at the bottom of the unit. The design of a centrifugal collector provides for a means of allowing the clean gas to exit through the top of the device. However, cyclones are inefficient at removing small particles.

Fabric filters/baghouses use a filter material to remove particles from a gas stream. The exhaust gas stream flows through filters/bags onto which particles are collected. Baghouses are typically employed for industrial applications to provide particulate emission control at relatively high efficiencies.

ESPs are used on a wide variety of industrial sources, including certain boilers. ESPs use electrical forces to move particles out of a flowing gas stream onto collector plates. The particles are given an electric charge by forcing them to pass through a region of gaseous ion flow called a "corona." An electrical field generated by electrodes at the center of the gas stream forces the charged particles to ESP's collecting plates.

Removal of the particles from the collecting plates is required to maintain sufficient surface area to clean the flowing gas stream. Removal must be performed in a manner to minimize re-entrainment of the collected particles. The particles are typically removed from the plates by "rapping" or knocking them loose, and collecting the fallen particles in a hopper below the plates.

Scrubber technology may also be employed to control PM in certain industrial applications. With wet scrubbers, flue gas passes through a water (or other solvent) stream, whereby particles in the gas stream are removed through inertial impaction and/or condensation of liquid droplets on the particles in the gas stream.

Step 2 - Eliminate Technically Infeasible Options

Pre-Combustion Control Technologies

The pre-combustion control technologies identified above (i.e., clean-burning, low-sulfur fuels, good combustion practices, high-efficiency filtration of the combustion turbine inlet and SCR dilution air systems) are available and technically feasible for reducing PM emissions from the combustion turbine exhaust streams.

Post-Combustion Control Technologies

Each of the post-combustion control technologies described above (i.e., cyclones, baghouses, ESPs, scrubbers) are generally available. However, none of these technologies is considered practical or technically feasible for installation on gaseous fuel-fired combustion turbines since $PM_{2.5}$, which, as stated above, makes up all of the PM emissions.

The particles emitted from gaseous fuel-fired are typically less than 1 micron in diameter. Cyclones are not effective on particles with diameters of 10 microns or less. Therefore, a cyclone/centrifugal collection device is not a technically feasible alternative.

Baghouses, ESPs, and scrubbers have never been applied to commercial combustion turbines burning gaseous fuels. Baghouses, ESPs, and scrubbers are typically used on solid or liquid-fuel fired sources with high PM emission concentrations, and are not used in gaseous fuel-fired applications, which have inherently low PM emission concentrations. None of these control technologies is appropriate for use on gaseous fuel-fired combustion turbines because of their very low PM emissions levels, and the small aerodynamic diameter of PM from gaseous fuel combustion. Review of the RBLC, as well as USEPA and State permit databases, indicates that post-combustion controls have not been required as BACT for gaseous fuel-fired fired combined-cycle combustion turbines. Therefore, the use of baghouses, ESPs, and scrubbers is not considered technically feasible.

Step 3 - Rank Remaining Control Technologies by Control Effectiveness

The use of clean-burning fuels, good combustion practices, and inlet air filtration are the technically feasible technologies to control PM_{10} and $PM_{2.5}$ emissions.

Step 4 - Evaluate Most Effective Controls and Document Results

Based on the information presented in this BACT analysis, using the proposed good combustion practices and inlet air filtration to control PM_{10} and $PM_{2.5}$ emissions is considered BACT. This is consistent with BACT at other similar sources. Therefore, an assessment of the economic and environmental impacts is not necessary.

It is noted, that a recent review by the Pennsylvania Department of Environmental Protection determined Best Available Technology (BAT) for large combustion turbines (> 5,000 hp) to be 0.03 lb/MMBtu. (See GP-5 Technical Support Document[iii].)

Step 5 - Select BACT

ACP, LLC proposes BACT for PM_{10} and $PM_{2.5}$ emissions from the combustion turbines is the use of clean-burning fuels, good combustion practices, and inlet air filtration to control PM_{10} and $PM_{2.5}$.

Emissions will be limited to 0.02 lb/MMBtu PM from each turbine.

6.2 *BACT FOR NITROGEN OXIDES (NO_X)*

NO_x emissions result from the proposed combustion turbines.

The following summarizes the BACT evaluation conducted for the Solar combustion turbines, the only significant equipment type for the Buckingham Compressor Station with respect to NO_x emissions.

Step 1 - Identify Potential Control Technologies

The potentially applicable controls to reduce NO_x emissions from turbines include:

- Dry Low NOx (DLN) Combustor Technology;
- Wet Controls - Water and Steam Injection;
- Selective Catalytic Reduction (SCR); and
- Selective Non-Catalytic Reduction (SNCR).

Additional control candidates available to control NO_x emissions from simple-cycle turbines, not listed in the EPA's Technology Transfer Network, include the following:

[iii] http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/gp/Technical_Support_Document_GP-5_4-9-2013.pdf

- Rich/Quench/Lean (RQL) Combustion;
- Catalytic Combustion - Xonon™;
- Catalytic Absorption (formally SCONOx™); and
- Alternate Lower FBN (fuel-bound nitrogen) Fuels.

Dry Low NOx (DLN) Combustors

DLN combustion control techniques reduce NO_x emissions without the use of water or steam injection. Two DLN combustion designs are available: lean pre-mixed combustion and rich/quench/lean staged combustion. Historically, gas turbine combustors were designed for operation with a 1:1 stoichiometric ratio (equal ratio of fuel and air). However, with fuel lean combustion (sub-stoichiometric conditions), the additional excess air cools the flame and reduces the rate of thermal NO_x formation. With reduced residence time combustors, dilution air is added sooner than with standard combustors resulting in the combustion gases attaining a high temperature for a shorter time, thus reducing the rate of thermal NOx formation. Pilot flames are used to maintain combustion stability to maintain the fuel-lean conditions.

Wet Controls - Water and Steam Injection

Water and steam injection directly into the flame area of the turbine combustor results in a lower flame temperature and reduces thermal NOx formation; however, fuel NOx formation is not reduced with this technique.

Selective Catalytic Reduction (SCR)

In the SCR process, ammonia (NH_3), usually diluted with air or steam, is injected through a grid system into the flue/exhaust gas stream upstream of a catalyst bed. The catalyst could be titanium dioxide, vanadium pentoxide or zeolite-based catalysts. On the catalyst surface, the NH_3 reacts with NO_x to form molecular nitrogen and water. The basic reactions are as follows:

$$4NH_3 + 4NO + O_2 = 4N_2 + 6H_2O$$

$$8NH_3 + 6NO_2 = 7N_2 + 12H_2O$$

Depending on system design and the inlet NOx level, NOx removal of can vary. The reaction of NH_3 and NOx is favored by the presence of excess oxygen. Another variable affecting NOx reduction is exhaust gas temperature. The greatest NOx reduction occurs within a reaction window at catalyst bed temperatures between 400°F and 800°F for base metal catalyst types (i.e., conventional SCR applications with lower temperature range platinum catalysts and with higher temperature range 550°F-800°F vanadium-titanium catalysts).

Selective Non-Catalytic Reduction (SNCR)

SNCR technology involves using ammonia or urea injection similar to SCR technology but at a much higher temperature window of 1,600°- 2,200°F. The following chemical reaction occurs without the presence of a catalyst:

$NOx + NH_3 + O_2 + H_2O + (H_2) = N_2 + H_2O$

The operating temperature can be lowered from 1,600°F to 1,300°F by injecting readily oxidizable hydrogen with the ammonia. However, beyond the upper temperature limit, the ammonia is converted to NOx, resulting in increased NOx emissions.

Rich/Quench/Lean (RQL) Combustion

RQL combustors burn fuel-rich in the primary zone and fuel-lean in the secondary zone, reduce both thermal and fuel NO_x. Incomplete combustion under fuel-rich conditions in the primary zone produces an atmosphere with a high concentration of CO and H_2, which replace some of the oxygen for NO_x formation and also act as reducing agents for any NO_x formed in the primary zone. Based on available test results, this control alternative is more effective for higher fuel-bound nitrogen fuels in retarding the rate of fuel NO_x formation.

Catalytic Combustion - Xonon™

Xonon™ is a catalytic combustion technology in development that reduces the production of NO_x. The technology has only been tested on small turbines (less than 10 MW) and it is still not commercially available for the proposed simple-cycle turbines. In a catalytic combustor, the fuel and air are premixed into a fuel-lean mixture and then passed into a catalyst bed. In the bed, the mixture oxidizes without forming a high-temperature flame front, thereby reducing peak combustion temperatures below 2,000^{0}F, which is the temperature at which significant amounts of thermal NO_x begin to form.

Catalytic Absorption (formally SCONOx™)

SCONOx™ , a post-combustion technology, proposes to remove NO_x from the exhaust gas stream following NO_x formation in combined cycle combustion turbine applications. While SCONOx™ has been marketed for more than ten years in the US, it has been installed and tested on only a handful of installations. SCONOx™ employs an oxidation catalyst followed by a potassium carbonate bed located within a heat recovery steam generator (to obtain the proper temperature window). The bed adsorbs NO_x where it reacts to form potassium nitrates. Periodically, a hydrogen gas stream is passed through individual sections of the catalyst, reacting with the potassium nitrates to reform potassium carbonate and the ejection of nitrogen gas and water.

Alternate Lower FBN (Fuel-Bound Nitrogen) Fuels

The utilization of a lower FBN fuel such as coal-derived gas or methanol is not deemed practical based on the nature of the proposed operations at the Buckingham Compressor Station. Thus, this control alternative is not addressed further in this BACT determination.

Step 2 - Eliminate Technically Infeasible Options

Dry Low NOx (DLN) Combustors

The proposed simple-cycle turbines at the Buckingham Compressor Station are Solar turbines equipped with SoLoNOx dry low NOx combustors. SoLoNOx uses lean combustion control technology to ensure uniform air/fuel mixture and to minimize formation of regulated pollutants while maintaining the same power and heat rate as equivalent models with conventional combustion technology.

Wet Controls - Water and Steam Injection

The water or steam injection rate is typically described on a mass basis by a water-to-fuel ratio (WFR) or steam-to-fuel ratio (SFR). Higher WFRs and SFRs translate to greater NO_x reductions, but may also cause potential flameouts, increasing maintenance requirements and reducing turbine efficiency. During startup and shutdown events for the simple-cycle turbines, introduction of water or steam injection into the proposed SoLoNOx dry low NO_x combustors would cause severe disruption to combustion dynamics and would likely result in damage to the combustion system and related components. Therefore, the use of water or steam injection will not be considered further in this BACT analysis for the turbines.

Selective Catalytic Reduction (SCR)

Base metal catalysts deteriorate quickly when continuously subjected to temperatures above this range or under thermal cycling, which commonly occurs in turbines in gas compression service. In effect, if these catalyst systems are operated beyond their specified temperature ranges, oxidation of the ammonia to either additional nitrogen oxides or ammonium nitrate may result. Moreover, the variable load demands on turbines in gas compression services create significant operational complexities for use of SCRs.

Based on a review of EPA's RBLC database, SCR systems have been installed on some simple cycle combustion turbines and are therefore considered technically feasible, and SCR is considered further in the BACT analysis.

Selective Non-Catalytic Reduction (SNCR)

The exhaust temperatures in gas turbines typically do not exceed 1,250°F. Therefore, the operative temperature window of this control alternative is not technically feasible for this application. Exhaust temperatures for the proposed gas turbines are approximately 900 °F, which is well below the range for SNCR applications. In addition, this technology has a residence time requirement of 100 milliseconds, which is relatively slow for gas turbine operating flow velocities. Thus, adequate residence time for the NOx destruction chemical reaction will not be available.

Further, a review of the RBLC database for recent BACT/LAER determinations for this particular source category and discussions with control system vendors do not indicate that SNCR systems have been successfully installed for NOx control for similar simple cycle turbines. In view of the above limitations in utilizing SNCR control, this control alternative is not considered technically feasible and will be precluded from further consideration in this BACT determination for the Buckingham Compressor Station turbines.

Rich/Quench/Lean (RQL) Combustion

Theoretically, this control alternative is applicable to natural gas-fired turbines; however, based on information presented in the EPA ACT (Alternative Control Techniques) document, RQL combustors are not commercially available for most turbine designs and there is no known application for only natural gas-fired simple-cycle combustion turbines. Because it is not commercially demonstrated on combustion turbines, RQL combustion will be removed from further consideration in this BACT determination for the turbines.

Catalytic Combustion – Xonon™

Catalytic converters are not commercially available for this application. Until such time that the technology is commercially available, catalytic combustors are not considered technically feasible. In addition, discussions with Solar indicated that this technology is not commercially available for any Solar product. In view of the above limitations in utilizing catalytic combustor control, this control alternative is precluded from further consideration in the Buckingham Compressor Station BACT determination.

Catalytic Absorption (formally SCONOx™)

The advantage of SCONOx™ relative to SCR is that SCONOx™ does not require ammonia injection to achieve NOx emissions control. However, the benefit of not using ammonia has been replaced by other potential operational problems that impair the effectiveness of the technology. First, the technology has not been demonstrated for larger turbines and the vendor's contention is still being debated; secondly, the technology is not readily adaptable to high-temperature applications outside the 300°-700°F range and is susceptible to potential thermal cycling; lastly, the potassium carbonate coating on the catalyst surface is an active chemical reaction and reformulation site, which makes it particularly vulnerable to fouling. In addition, based on review of EPA's RBLC database and other permits issued in different states, this technology has not been applied on simple cycle combustion turbines used for natural gas compression. Therefore, this technology is not considered further in the BACT analysis.

Step 3 - Rank Remaining Control Technologies by Control Effectiveness

The control technologies, which have been demonstrated in commercial practice on turbines are:

- Dry Low NOx Combustor Technology, SoLoNOx Technology; and
- Selective Catalytic Reduction

Step 4 - Evaluate Most Effective Controls and Document Results

ACP, LLC is proposing installation of SCR for the turbines at the Buckingham Compressor Station. For the types and designs of turbines proposed for this project at the Buckingham Compressor Station, SCR is commonly disqualified from BACT through cost effectiveness calculations. For example, see recent Pennsylvania analysis documented in the GP-5 Technical Support Document[iv] that established 15 ppmvd @ 15% O_2 as BAT for turbines rated at 5,000 hp or greater.

Based on the information presented in this BACT analysis, the use of low NO_x combustion technology (SoLoNOx) and good combustion practices were the most common control option proposed for turbines similar to the proposed turbines in this project.

Step 5 - Select BACT

The proposed Buckingham Compressor Station turbines will be equipped with SoLoNOx dry low NO_x combustors with a vendor performance specification for NO_x emission rate of 9 ppmvd @ 15% O_2. Therefore, the use of SoLoNOx dry low NO_x combustors and good combustion practices is considered BACT for reducing NO_x emissions from the proposed Buckingham Compressor Station turbines.

In addition to the BACT controls proposed, ACP, LLC plans to install SCR on the proposed Buckingham Compressor Station turbines and to further reduce emissions to 5 ppmvd NO_x @ 15% O_2 during normal operation.

[iv] http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/gp/Technical_Support_Document_GP-5_4-9-2013.pdf

6.3 *BACT FOR CARBON MONOXIDE (CO)*

CO emissions result from the proposed combustion turbines.

The following summarizes the BACT evaluation conducted for the Solar combustion turbines, the only significant equipment type for the Buckingham Compressor Station with respect to CO emissions.

Step 1 - Identify Potential Control Technologies

Based upon a search of nationally permitted control technology options conducted using the RBLC Clearinghouse, the following control options are available control candidates for simple-cycle turbines combusting natural gas:

- Combustion Control;
- Catalytic Oxidation/Absorption (formally SCONOx™); and
- CO Oxidation Catalysts.

Combustion Control

Because CO is essentially a by-product of incomplete or inefficient combustion, it is important that combustion control constitutes the primary mode of reduction of CO emissions. As discussed above, the SoLoNOx dry low NOx combustors use lean combustion control technology to ensure uniform air/fuel mixture and to minimize formation of regulated pollutants while maintaining the same power and heat rate as equivalent models with conventional combustion technology. SoLoNOx combustor technology not only ensures significant NO_x reductions but also achieves some reduction in CO emissions.

The basic premise of the technology involves premixing the fuel and air prior to entering the combustion zone, which provides for a uniform fuel/air mixture and prevents local hotspots in the combustor, thereby reducing NO_x emissions. However, the residence time of the combustion gases in these lean premixed combustors must be increased to ensure complete combustion of the fuel to minimize CO emissions.

Catalytic Absorption (formally SCONOx™)

SCONOx is a post combustion technology that, along with NO_x reductions, results in almost 100% removal of CO. As discussed in the NO_x BACT, SCONOx is deemed technically infeasible and will not be considered further.

CO Oxidation Catalyst

Oxidation catalyst systems serve to remove CO (and VOC) from the turbine exhaust gas rather than limiting pollutant formation at the source. The technology does not require introduction of additional chemicals for the reaction to proceed. The oxidation of CO to CO_2 uses the excess air present in the turbine exhaust, and the activation energy required for the reaction to proceed is lowered in the presence of the catalyst.

Step 2 - Eliminate Technically Infeasible Options

Combustion Control

Combustion control is considered technically feasible.

Catalytic Absorption (formally SCONOx™)

As discussed in the NO_x BACT, SCONOx is deemed technically infeasible and will not be considered further.

CO Oxidation Catalyst

CO oxidation catalyst is considered technically feasible.

Step 3 - Rank Remaining Control Technologies by Control Effectiveness

The control technologies, which have been demonstrated in commercial practice on the types of turbines proposed for this project and their associated estimated control efficiencies, are summarized below:

- Dry Low NOx Combustor Technology, SoLoNOx Technology - 25 ppmvd CO @ 15% O_2.
- CO Oxidation Catalyst

Step 4 - Evaluate Most Effective Controls and Document Results

For the types and designs of turbines proposed for the Buckingham Compressor Station, oxidation catalysts are commonly disqualified from BACT through cost effectiveness calculations. For example, a recent review by the Pennsylvania Department of Environmental Protection determined oxidation catalyst technology to be cost prohibitive for CO control. BAT for large combustion turbines was determined to be 25 ppmvd @ 15% O2 as BAT for CO for turbines rated equal to or greater than 1,000 hp and less than 5,000 bhp. (as propane) @ 15% O_2 for non-methane, non-ethane hydrocarbons. (See GP-5 Technical Support Document[v].)

[v] http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/gp/Technical_Support_Document_GP-5_4-9-2013.pdf

Based on the information presented in this BACT analysis, the combustion technology (SoLoNOx) and good combustion practices were the most common control option proposed for turbines similar to the proposed turbines in this project.

Step 5 - Select BACT

ACP, LLC plans to install turbines which will be equipped with SoLoNOx dry low NO_x combustors which will achieve a guaranteed CO emission rate of 25 ppmvd @ 15% O_2. Therefore, SoLoNOx combustors combined with good combustion practices is considered BACT for limiting CO emissions from the proposed turbines.

In addition to the BACT controls proposed, ACP, LLC plans to install oxidation catalysts on the proposed Buckingham Compressor Station turbines. The estimated efficiency of the oxidation catalyst will be approximately 80% control for CO, to further reduce emissions to 5 ppmvd CO @ 15% O_2 during normal operation.

6.4 *BACT FOR VOLATLE ORGANIC COMPOUNDS (VOC)*

The following summarizes the BACT evaluation conducted for each significant piece of equipment with respect to VOC emissions. For the Buckingham Compressor Station, this includes combustion turbines and fugitive emissions sources.

6.4.1 *Combustion Turbines*

The available emission control options for minimizing VOC emissions from the turbines include:

- Good combustion practices; and
- Oxidation catalyst .

For the types and designs of turbines proposed for the Buckingham Compressor Station, oxidation catalysts are commonly disqualified from BACT through cost effectiveness calculations. For example, a recent review by the Pennsylvania Department of Environmental Protection determined oxidation catalyst technology to be cost prohibitive for VOC control. BAT for large combustion turbines was determined to be 9 ppmvd (as propane) @ 15% O_2 for non-methane, non-ethane hydrocarbons. (See GP-5 Technical Support Document[vi].)

[vi] http://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Permits/gp/Technical_Support_Document_GP-5_4-9-2013.pdf

For this project, oxidation catalyst will be installed on each turbine (to minimize CO emissions). VOC emissions will be reduced as part of the oxidation process. The oxidation catalyst is expected to achieve approximately 50% control efficiency for VOC. Good combustion practices alone are considered BACT for VOC emissions.

VOC emissions will be limited to 1.3 ppmvd @ 15% O_2 from the turbines.

6.4.2 *Fugitives*

The available emission control options for minimizing VOC fugitive emissions from the turbines include operation according to ACP, LLC and the manufacturer's best practices.

ACP, LLC will minimize blowdown events, which create the majority of fugitive emissions, whenever possible, but blowdown of the machines and piping will sometimes occur for safety reasons and to ensure protection of equipment.

As described in Section 4.1, ACP, LLC expects to comply with NSPS Subpart OOOOa when promulgated and proposes compliance with the applicable fugitive leak provisions of Subpart OOOOa as BACT.

7.0 *PROPOSED COMPLIANCE DEMONSTRATIONS*

The following methods are proposed for demonstrating ongoing compliance for the sources described in this application:

<u>Compressor Turbines (CT-01 through CT-04)</u>

NO_x

Annual stack testing (or semi-annual testing as allowed) will be completed to demonstrate compliance with the NSPS Subpart KKKK emissions limits (NO_2 emissions).

Compliance with the combustion turbines potential to emit will be demonstrated on a 12-month rolling total basis by the sum of the following emissions:

- Normal Operation: The average emission rate from the most recent stack test (lb/hour) times the number of hours operating in SoLoNOx mode (mode indication provided and recorded by control logic on turbine).
- Low Temperature (< 0° F) Operation: The proposed controlled emission rates (lb/hr, see Table 3.2) determined using the Solar provided emissions factor multiplied by the control efficiency of the SCR times the number of hours when inlet combustion air for turbine was measured to be below 0 degrees F.
- Startup and Shutdown Emissions (< 50% load): The Solar-provided emission rates (see Tables 3.3 and 3.4) divided by Solar-assumed duration for startups and shutdowns (1/6 of an hour each) times the number of hours operating in non-SoLoNOx mode (mode indication provided and recorded by control logic on the turbine).

CO, VOC, $PM_{10}/PM_{2.5}$:

Initial stack testing will be completed to determine $PM_{10}/PM_{2.5}$ emission rates (lb/MMBtu). Fuel firing will be tracked and used to calculate annual (rolling 12-month total) ton per year emissions.

Initial stack testing will be competed to determine VOC and CO emission rates. Compliance with the combustion turbines potential to emit will be demonstrated on a 12-month rolling total basis by the sum of the following emissions:

- Normal Operation: The average emission rate from the most recent stack test (lb/hour) times the number of hours operating in SoLoNOx mode (mode indication provided and recorded by control logic on turbine).

- Low Temperature (< 0° F) Operation: The proposed controlled emission rates (lb/hr, see Table 3.2) determined using the Solar provided emissions factor multiplied by the control efficiency of the oxidation catalyst times the number of hours when inlet combustion air for turbine was measured to be below 0 degrees F.

- Startup and Shutdown Emissions (< 50% load): The Solar-provided emission rates (see Tables 3.3 and 3.4) divided by Solar-assumed duration for startups and shutdowns (1/6 of an hour each) times the number of hours operating in non-SoLoNOx mode (mode indication provided and recorded by control logic on the turbine).

GHG:

Total annual fuel volume will be tracked to determine total MMBtu of firing. This value times the EPA Mandatory Reporting Rule natural gas emission factor (40 CFR Part 98 Subpart C) times the Global Warming Potential (40 CFR Part 98 Subpart A) will be used to calculate ton per year CO_2e emissions.

<u>Line Heaters (LH-01 through LH-04)</u>

The units will maintain compliance with NSPS Subpart Dc (maintain records of fuel fired daily and sulfur content of gas).

<u>Other Combustion Sources</u>

If not otherwise specified above, the amount of fuel fired in units and/or hours of operation will be tracked and multiplied by the appropriate emission factor to calculate emissions on an annual basis.

APPENDICES

APPENDIX A

VIRGINIA DEQ FORM 7 APPLICATION FORMS

PERMIT FORMS
PURSUANT TO
REGULATIONS FOR THE CONTROL AND ABATEMENT OF AIR POLLUTION

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY

AIR PERMITS
FORM 7 APPLICATION

NEW SOURCE REVIEW PERMITS
and STATE OPERATING PERMITS

What pages do I fill out for my facility?

- All new sources and major modifications: 3
- All new and modified sources (except for true minors): 4
- All new and modified sources and State Operating Permits: 7, 8, 9
- All new and modified major sources: 25, 26, 27, 28, 29

In addition, complete the following pages:

- For boilers, external combustion units, turbines: 10, (19, 20 if applicable), 21, 22, 23, 24, 30
- For stationary combustion engines: 11, (19, 20 if applicable), 21, 22, 30
- For incinerators: 12, 19, 20, 21, 22, 23, 24, 30
- For surface coating operations: 13, 14, (19, 20 if applicable), 21, 22, 23, 24, 30
- For quarry operations: 13, 19, 20, 21, 22
- For VOC/Petroleum storage tanks: 15, 16, 21, 22, 23, 24, 30
- For loading racks and oil water separators: 17, 21, 22, 23, 24, 30
- For fumigation operations: 18
- For all other sources: 13, (19, 20, 23, 24 if applicable), 21, 22, 30

****NOTE:** ***The facility only has to fill out the applicable pages that apply.*** If any pages are unused, the facility does not need to submit the unused pages with the application.

Source-Specific Form 7 Applications

There are some source-specific Form 7 Applications available for these sources:
(check out the DEQ website at http://www.deq.virginia.gov/Programs/Air/Forms.aspx)

- Asphalt plants (Form 7A)
- Crematories (Form 7B)
- Concrete Batch Plant (Form 7C)

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VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY - AIR PERMITS

LOCAL GOVERNING BODY CERTIFICATION FORM

Facility Name: ACP-2 Compressor Station	Registration Number: N/A
Applicant's Name: Atlantic Coast Pipeline, LLC	Name of Contact Person at the site: William Scarpinato
Applicant's Mailing address: 707 East Main Street Richmond, Virginia 23219	Contact Person Telephone Number: 804-273-3019

Facility location (also attach map):
Buckingham County, Virginia

Facility type, and list of activities to be conducted:
Natural gas compression and transmission station; Atlantic Coast Pipeline, LLC proposes to construct and operate via Dominion Transmission, Inc. (DTI) an approximately 556-mile long interstate natural gas transmission pipeline system to meet growing energy needs in Virginia and North Carolina. The ACP-2 Station will provide compression to support the transmission of natural gas. The adjacent metering and regulation (M&R) station (Woods Corner) will also be operated by DTI and will be considered part of the ACP-2 Station.

The applicant is in the process of completing an application for an air pollution control permit from the Virginia Department of Environmental Quality. In accordance with § 10.1-1321.1. Title 10.1, Code of Virginia (1950), as amended, before such a permit application can be considered complete, the applicant must obtain a certification from the governing body of the county, city or town in which the facility is to be located that the location and operation of the facility are consistent with all applicable ordinances adopted pursuant to Chapter 22 (§§ 15.2-2200 et seq.) of Title 15.2. The undersigned requests that an authorized representative of the local governing body sign the certification below.

Applicant's signature: [signature]	Date: 8/26/15

The undersigned local government representative certifies to the consistency of the proposed location and operation of the facility described above with all applicable local ordinances adopted pursuant to Chapter 22 (§§15.2-2200 et seq.) of Title 15.2. of the Code of Virginia (1950) as amended, as follows:

(Check one block)

☒ The proposed facility is **fully consistent** with all applicable local ordinances upon obtaining a Special Use Permit from the County of Buckingham Va

☐ The proposed facility is **inconsistent** with applicable local ordinances; see attached information.

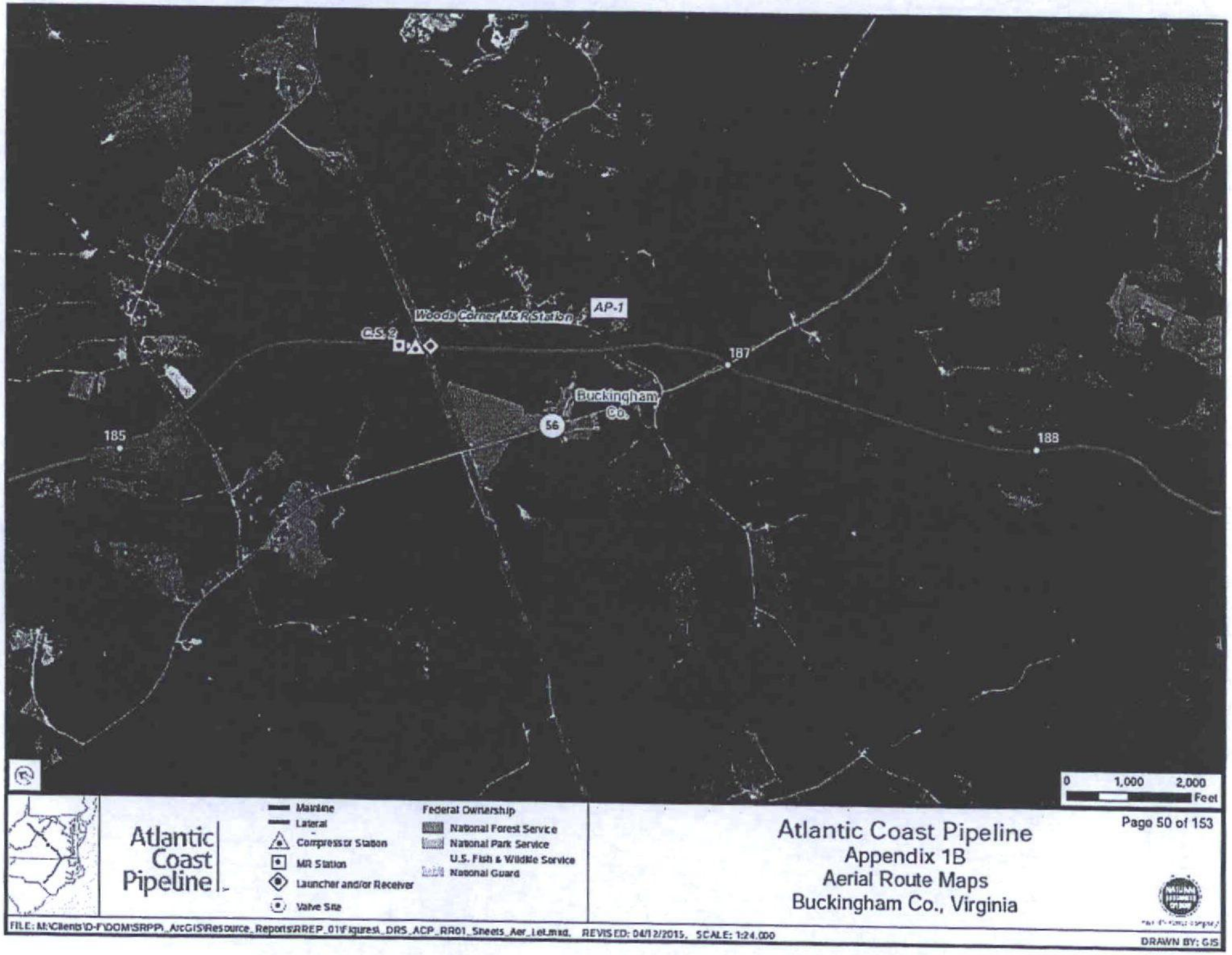
Signature of authorized local government representative: [signature] Rebecca S Carter	Date: 09/08/2015
Type or print name: REBECCA S CARTER	Title: County Administrator

County, city or town:
Buckingham County

[THE LOCAL GOVERNMENT REPRESENTATIVE SHOULD FORWARD THE SIGNED CERTIFICATION TO THE APPROPRIATE DEQ REGIONAL OFFICE AND SEND A COPY TO THE APPLICANT.]

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY – 2015 AIR PERMIT APPLICATION FEE

FIGURE 2.1 ATLANTIC COAST PIPELINE PROJECT – ACP-2 STATION LOCATION



As of July 1, 2012, air permit applications are subject to a fee. The fee does not apply to administrative amendments or true minor sources. Applications will be considered incomplete if the proper fee is not paid and will not be processed until full payment is received. Air permit application fees are not refundable.
Fees are adjusted every January 1st for CPI. THIS FORM IS VALID JANUARY 1, 2015 TO DECEMBER 31, 2015.
Send this form and a check (or money order) payable to "Treasurer of Virginia" to:
Department of Environmental Quality
Receipts Control
P.O. Box 1104
Richmond, VA 23218

Send a copy of this form with the permit application to:
The DEQ Regional Office

Please retain a copy for your records. Any questions should be directed to the DEQ regional office to which the application will be submitted. **Unsure of your fee? Contact the Regional Air Permit Manager.**

COMPANY NAME:	**Atlantic Coast Pipeline, LLC**	**FIN:**	
COMPANY REPRESENTATIVE:	**William Scarpinato**	**REG. NO.**	**NA**
MAILING ADDRESS:	**5000 Dominion Blvd Glen Allen, VA 23060**		
BUSINESS PHONE:	**(804) 273-3019**	**FAX:**	
FACILITY NAME:	**Buckingham Compressor Station**		
PHYSICAL LOCATION:	**Buckingham County, VA**		

PERMIT ACTIVITY	APPLICATION FEE AMOUNT	CHECK ONE
Sources subject to Title V permitting requirements:		
• Major NSR permit (Articles 7, 8, 9)	$31,497	
• Major NSR permit amendment (Articles 7, 8, 9)*	$7,349	
• State major permit (Article 6)	$15,748	
• Title V permit (Articles 1, 3)	$20,998	
• Title V permit renewal (Articles 1, 3)	$10,499	
• Title V permit modification (Articles 1, 3)	$3,674	
• Minor NSR permit (Article 6)	$1,574	x
• Minor NSR amendment (Article 6)*	$787	
• State operating permit (Article 5)	$7,349	
• State operating permit amendment (Article 5)*	$3,674	
Sources subject to Synthetic Minor permitting requirements:		
• Minor NSR permit (Article 6)	$524	
• Minor NSR amendment (Article 6)*	$262	
• State operating permit (Article 5)	$1,574	
• State operating permit amendment (Article 5)*	$839	
***FEES DO NOT APPLY TO ADMINISTRATIVE AMENDMENTS**		

DEQ OFFICE TO WHICH PERMIT APPLICATION WILL BE SUBMITTED (check one)

☐ **SWRO/Abingdon**	☐ **NRO/Woodbridge**	☐ **PRO/Richmond**	**FOR DEQ USE ONLY** **Date:** ________ **DC #:** ________
☐ **VRO/Harrisonburg**	☒ **BRRO/Lynchburg or Roanoke**	☐ **TRO/Virginia Beach**	**Reg. No.:** ________

APPLICATION FEE FORM DEFINITIONS:

Administrative amendment – An administrative change to a permit issued pursuant to Article 1 (9 VAC 5-80-50 et seq.), Article 3 (9 VAC 5-80-360 et seq.), Article 5 (9 VAC 5-80-800 et seq.), Article 6 (9 VAC 5-80-1100 et seq.), Article 7 (9 VAC 5-80-1400 et seq.), Article 8 (9 VAC 5-80-1605 et seq.), or Article 9 (9 VAC 5-80-2000 et seq.) of 9 VAC 5 Chapter 80. Administrative amendments include, but are not limited to, the following:

- Corrections of typographical or any other error, defect or irregularity which does not substantially affect the permit,
- Identification of a change in the name, address, or phone number of any person identified in the permit, or of a similar minor administrative change at the source,
- Change in ownership or operational control of a source where the board determines that no other change in the permit is necessary, provided that a written agreement containing a specific date for transfer of permit responsibility, coverage, and liability between the current and new permittee has been submitted to the board.

Major new source review permit (Major NSR permit) – A permit issued pursuant to Article 7 (9 VAC 5-80-1400 et seq.), Article 8 (9 VAC 5-80-1605 et seq.), or Article 9 (9 VAC 5-80-2000 et seq.) of 9 VAC 5 Chapter 80. For purposes of fees, the Major NSR permit also includes applications for projects that are major modifications.

- An Article 7 permit is a preconstruction review permit (case-by-case Maximum Achievable Control Technology (MACT) determination) for the construction or reconstruction of any stationary source or emission unit that has the potential to emit, considering controls, 10 tons per year or more of any individual hazardous air pollutant (HAP) or 25 tons per year or more of any combination of HAPs and EPA has not promulgated a MACT standard or delisted the source category.
- An Article 8 permit is for a source (1) with the potential to emit over 250 tons per year of a single criteria pollutant OR (2) is in one of the listed source categories under 9 VAC 5-80-1615 and has the potential to emit over 100 tons per year of any criteria pollutant OR (3) with the potential to emit over 100,000 tons per year of CO_2 equivalent (CO_2e) (9 VAC 5-85 Part III). PSD permits are issued in areas that are in attainment of the National Ambient Air Quality Standards.
- An Article 9 permit is a preconstruction review permit for areas that are in nonattainment with a National Ambient Air Quality Standard (NAAQS). Nonattainment permits are required by any major new source that is being constructed in a nonattainment area and is major for the pollutant for which the area is in nonattainment. Nonattainment permitting requirements may also be triggered if an existing minor source makes a modification that results in the facility being major for the pollutant for which the area is in nonattainment. A major source is any source with potential to emit over 250 tons per year of a single criteria pollutant or is in one of the listed source categories under 9 VAC 5-80-2010 and the potential to emit over 100 tons per year of any criteria pollutant. However, if any area is in nonattainment for a specific pollutant, the major source threshold may be lower for that pollutant. For example, sources locating in the Northern Virginia Ozone Nonattainment Area which are part of the Ozone Transport Region would be a major source if they have the potential to emit more than 100 tons per year of NO_X and/or 50 tons per year of VOC regardless of source category. Nonattainment permits do not require an air quality analysis but require a source to control to the Lowest Achievable Emission Rate (LAER) and to obtain offsets.

Major NSR permit amendment – A change to a permit issued pursuant to Article 7 (9 VAC 5-80-1400 et seq.), Article 8 (9 VAC 5-80-1605 et seq.), or Article 9 (9 VAC 5-80-2000 et seq.) of 9 VAC 5 Chapter 80. Only minor amendments and significant amendments are included in this category.

Minor new source review permit (Minor NSR permit) – A permit to construct and operate issued under Article 6 (9 VAC 5-80-1100 et seq.) of 9 VAC 5 Chapter 80. Minor NSR permits are 1) categorically required; or 2) issued to sources whose uncontrolled emission rate for a regulated criteria pollutant is above exemption thresholds and permitting allowables are below Title V thresholds, and/or 3) issued to sources whose potential to emit for a toxic pollutant is above state toxic exemption thresholds and permitting allowables are below Title V thresholds. The minor NSR permit can be used to establish synthetic minor limits for avoidance of state major, PSD and/or Title V permits. For purposes of fees, the Minor NSR permit also includes exemption applications and applications for projects at existing sources.

Minor NSR amendment - A change to a permit issued pursuant to Article 6 (9 VAC 5-80-1100 et seq.) of 9 VAC 5 Chapter 80. Only minor amendments and significant amendments are included in this category.

Sources subject to Synthetic Minor permitting requirements - Stationary sources whose potential to emit exceeds the Title V threshold (100 tons per year of a criteria pollutant, 10/25 tpy of HAPs, and/or 100,000 tpy CO_2e) but have taken federally enforceable limits, either through a state operating permit or a minor NSR permit, to avoid Title V permit applicability.

Sources subject to Title V permitting requirements – Stationary sources that have a potential to emit above the Title V thresholds or are otherwise applicable to the Title V permitting program.

State major permit – A permit to construct and operate issued under Article 6 (9 VAC 5-80-1100 et seq.) of 9 VAC 5 Chapter 80. State major permits are for facilities that have an allowable emission rate of more than 100 tons per year, but less than 250 tons per year, of any criteria pollutant and are not listed in the 28 categories under "major stationary source" as defined in 9 VAC 5-80-1615.

State operating permit (SOP) – A permit issued under Article 5 (9 VAC 5-80-800 et seq.) of 9 VAC 5 Chapter 80. SOPs are most often used by stationary sources to establish federally enforceable limits on potential to emit to avoid major New Source Review permitting (PSD and Nonattainment permits), Title V permitting, and/or major source MACT applicability. SOPs can also be used to combine multiple permits from a stationary source into one permit or to implement emissions trading requirements. The State Air Pollution Control Board, at its discretion, may also issue SOPs to cap the emissions of a stationary source or emissions unit causing or contributing to a violation of any air quality standard or to establish a source-specific emission standard or other requirement necessary to implement the federal Clean Air Act or the Virginia Air Pollution Control Law.

SOP permit amendment - A change to a permit issued pursuant to Article 5 (9 VAC 5-80-800 et seq.) of 9 VAC 5 Chapter 80. Only minor amendments and significant amendments are included in this category.

Title V permit – A federal operating permit issued pursuant to Article 1 (9 VAC 5-80-50 et seq.) or Article 3 (9 VAC 5-80-360 et seq.) of 9 VAC 5 Chapter 80. Facilities which (1) have the potential to emit of air pollutants above the major source thresholds, listed in 9 VAC 5-80-60 OR (2) are area sources of hazardous air pollutants, not explicitly exempted by EPA OR (3) have the potential to emit over 100,000 tons per year of CO_2 equivalent (CO_2e) (9 VAC 5-85 Part III), are required to obtain a Title V permit. For purposes of fees, the Title V permit also includes Acid Rain (Article 3) permit applications.

Title V permit modification - A change to a permit issued pursuant to Article 1 (9 VAC 5-80-50 et seq.) or Article 3 (9 VAC 5-80-360 et seq.) of 9 VAC 5 Chapter 80. Only minor modifications and significant modifications are included in this category.

Title V permit renewal – A renewal of a Title V permit pursuant to Article 1 (9 VAC 5-80-50 et seq.) of 9 VAC 5 Chapter 80. Title V permits are renewed every 5 years and a renewal application must be submitted to the regional office no sooner than 18 months and no later than 6 months prior to expiration of the Title V permit. For purposes of fees, the Title V permit renewal also includes Acid Rain (Article 3) permit renewal applications.

True minor source – A source that does not have the physical or operational capacity to emit major amounts (even if the source owner and regulatory agency disregard any enforceable limits). For further information, click here.

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AIR PERMIT APPLICATION
CHECK ALL PAGES ATTACHED AND LIST ALL ATTACHED DOCUMENTS

- 1 Local Government Certification Form, Page 3
- 1 Application Fee Form, Pages 4-6
- 1 Document Certification Form, Page 7
- 1 General Information, Pages 8-9
- 1 Fuel Burning Equipment, Page 10
- 1 Stationary Internal Combustion Engines, Page 11
- ___ Incinerators, Page 12
- ___ Processing, Page 13
- ___ Inks, Coatings, Stains, and Adhesives, Page 14
- 1 VOC/Petroleum Storage Tanks, Pages 15-16
- ___ Loading Rack and Oil-Water Separators, Page 17
- ___ Fumigation Operations, Page 18
- 1 Air Pollution Control and Monitoring Equipment, Page 19
- 1 Air Pollution Control/Supplemental Information, Page 20
- 1 Stack Parameters and Fuel Data, Page 21
- 1 Proposed Permit Limits for Criteria Pollutants, Page 22
- 1 Proposed Permit Limits for Toxic Pollutants/HAPs, Page 23
- ___ Proposed Permit Limits for Other Reg. Pollutants, Page 24
- ___ Proposed Permit Limits for GHGs on Mass Basis, Page 25
- ___ Proposed Permit Limits for GHGs on CO_2e Basis, Page 26
- ___ BAE for Criteria Pollutants, Page 27
- ___ BAE for GHGs on Mass Basis, Page 28
- ___ BAE for GHGs on CO_2e Basis, Page 29
- 1 Operating Periods, Page 30

5 ATTACHED DOCUMENTS:

- ___ Map of Site Location
- 1 Facility Site Plan
- ___ Process Flow Diagram/Schematic
- ___ MSDS or CPDS Sheets
- 1 Estimated Emission Calculations
- ___ Stack Tests
- ___ Air Modeling Data
- ___ Confidential Information (see Instructions)
- 1 BACT Analysis
- 1 Vendor Specifications
- 1 Permit Application Narrative

Check added form sheets above; also indicate the number of copies of each form in blank provided.

DOCUMENT CERTIFICATION FORM

I certify under penalty of law that this document and all attachments [as noted above] were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

I certify that I understand that the existence of a permit under [Article 6 of the Regulations] does not shield the source from potential enforcement of any regulation of the board governing the major NSR program and does not relieve the source of the responsibility to comply with any applicable provision of the major NSR regulations.

SIGNATURE: ____________ DATE: 9/11/15

NAME: Leslie Hartz REGISTRATION NO: ____________

TITLE: VP Pipeline Construction COMPANY: Atlantic Coast Pipeline, LLC.

PHONE: (804) 771-4468 ADDRESS: 707 E. Main Street

EMAIL: leslie.hartz@dom.com Richmond, VA 23219

References: Virginia Regulations for the Control and Abatement of Air Pollution (Regulations), 9 VAC 5-20-230B and 9 VAC 5-80-1140E.

GENERAL INFORMATION

Person Completing Form: Robert Sawyer	Date: 09/2015	Registration Number: NA
Company and Division Name: Environmental Resources Management		FIN:
Mailing Address: 200 Harry S. Truman Pkwy Suite 400 Annapolis, MD 21401		
Exact Source Location – Include Name of City (County) and Full Street Address or Directions: Buckingham County, Virginia		
Telephone Number: (410) 266-0006	No. of Employees:	Property Area at Site:
Person to Contact on Air Pollution Matters – Name and Title: William Scarpinato	Phone Number: (804) 273-3019 Fax: Email:	
Latitude and Longitude Coordinates **OR** UTM Coordinates of Facility: Latitude: 37°35'23.29" Longitude: 78°39'31.48"		

Reason(s) for Submission (Check all that apply):

☐ State Operating Permit — This permit is applied for pursuant to provisions of the Virginia Administrative Code, 9 VAC 5 Chapter 80, Article 5 (SOP)

☒ New Source
☐ Modification of a Source
☐ Relocation of a Source

This permit is applied for pursuant to the following provisions of the Virginia Administrative Code:
☒ 9 VAC 5 Chapter 80, Article 6 (Minor Sources)
☐ 9 VAC 5 Chapter 80, Article 8 (PSD Major Sources)
☐ 9 VAC 5 Chapter 80, Article 9 (Non-Attainment Major Sources)

☐ Amendment to a Permit Dated: ________ Permit Type: ☐ SOP (Art. 5) ☐ NSR (Art. 6, 8, 9)

Amendment Type:
☐ Administrative Amendment
☐ Minor Amendment
☐ Significant Amendment

This amendment is requested pursuant to the provisions of:

☐ 9 VAC 5-80-970 (Art. 5 Adm.)	☐ 9 VAC 5-80-1935 (Art. 8 Adm.)
☐ 9 VAC 5-80-980 (Art. 5 Minor)	☐ 9 VAC 5-80-1945 (Art. 8 Minor)
☐ 9 VAC 5-80-990 (Art. 5 Sig.)	☐ 9 VAC 5-80-1955 (Art. 8 Sig.)
☐ 9 VAC 5-80-1270 (Art. 6 Adm.)	☐ 9 VAC 5-80-2210 (Art. 9 Adm.)
☐ 9 VAC 5-80-1280 (Art. 6 Minor)	☐ 9 VAC 5-80-2220 (Art. 9 Minor)
☐ 9 VAC 5-80-1290 (Art. 6 Sig.)	☐ 9 VAC 5-80-2230 (Art. 9 Sig.)

☐ Other (specify): ____________________

Explanation of Permit Request (attach documents if needed):

Atlantic Coast Pipeline, LLC (ACP, LLC) proposes to construct and operate the Buckingham Compressor Station in Buckingham County, Virginia to provide compression to support the transmission of natural gas. An adjacent metering and regulating (M&R) station (Woods Corner) has been included as part of this application for the Buckingham Compressor Station.

APC, LLC submits this Article 6 permit application to the Virginia Department of Environmental Quality (DEQ), Blue Ridge Regional Office for the authority to construct the Buckingham Compressor Station in Buckingham County, Virginia. Please see the attached permit application narrative for clarification and/or further detail to the information in these permit application forms provided by the DEQ.

GENERAL INFORMATION (CONTINUED)

For Portable Plants:

Is this facility designed to be portable? ☐ Yes ☒ No

- If yes, is this facility already permitted as a portable plant? ☐ Yes ☐ No Permit Date: ______

If not permitted, is this an application to be permitted as a portable plant? ☐ Yes ☒ No

If permitted as a portable facility, is this a notification of relocation? ☐ Yes ☐ No

- Describe the new location or address (include a site map): ______
- Will the portable facility be co-located with another source? ☐ Yes ☐ No Reg. No. ______
- Will the portable facility be modified or reconstructed as a result of the relocation? ☐ Yes ☐ No
- Will there be any new emissions other than those associated with the relocation? ☐ Yes ☐ No
- Is the facility suitable for the area to which it will be located? (attach documentation) ☐ Yes ☐ No

Describe the products manufactured and/or services performed at this facility:

The facility serves as a natural gas compression and transmission station along the Atlantic Coast Pipeline (ACP), helping to deliver natural gas from Pennsylvania and West Virginia to Virginia and North Carolina.

List the Standard Industrial Classification (SIC) Code(s) for the facility:

4	9	2	2

List the North American Industry Classification System (NAICS) Code(s) for the facility:

4	8	6	2	1	0

List all the facilities in Virginia under common ownership or control by the owner of this facility:

Milestones: This section is to be completed if the permit application includes a new emissions unit or modification to existing operations.

Milestones*:	Starting Date:	Estimated Completion Date:
New Equipment Installation	April 2017	November 2018
Modification of Existing Process or Equipment		
Start-up Dates		

*For new or modified installations to be constructed in phased schedule, give construction/installation starting and completion date for each phase.

FUEL BURNING EQUIPMENT: (Boilers, Turbines, Kilns, and Other External Combustion Units)

Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Equipment Manufacturer, Type, and Model Number	Date of Manuf.	Date of Const.	Max. Rated Input Heat Capacity For Each Fuel (Million Btu/hr)	Type of Fuel	Type of Equip. (use Code A)	Usage (use Code B)	Requested Throughput* (hrs/yr OR fuel/yr)	Federal Regulations that Apply
WH-01	Boiler (Manufacturer and Model Number TBD)	TBD	4/1/17	9.5	Natural Gas	12	3	8,760 hrs/yr	40 CFR Part 98
LH-01	ETI, Line Heater, WB HTR		4/1/17	17	Natural Gas	12	4	8,760 hrs/yr	40 CFR Part 98 40 CFR 60 Subpart Dc
LH-02	ETI, Line Heater, WB HTR		4/1/17	17	Natural Gas	12	4	8,760 hrs/yr	40 CFR Part 98 40 CFR 60 Subpart Dc
LH-03	ETI, Line Heater, WB HTR		4/1/17	17	Natural Gas	12	4	8,760 hrs/yr	40 CFR Part 98 40 CFR 60 Subpart Dc
LH-04	ETI, Line Heater, WB HTR		4/1/17	17	Natural Gas	12	4	8,760 hrs/yr	40 CFR Part 98 40 CFR 60 Subpart Dc

[X] Estimated Emission Calculations Attached (include references of emission factors) and/or Stack Test Results if Available

Code A – Equipment

BOILER TYPE:
1. Pulverized Coal - Wet Bottom
2. Pulverized Coal - Dry Bottom
3. Pulverized Coal - Cyclone Furnace
4. Circulating Fluidized Bed
5. Spreader Stoke
6. Chain or Travelling Grate Stoker
7. Underfeed Stoker
8. Hand Fired Coal
9. Oil, Tangentially Fired
10. Oil, Horizontally Fired (except rotary cup)
11. Gas, Tangentially Fired
12. Gas, Horizontally Fired
13. Wood with Flyash Reinjection
14. Wood without Flyash Reinjection
15. Other (specify) ____________

OTHER COMBUSTION UNITS:
16. Oven / Kiln
17. Rotary Kiln
18. Process Furnace
19. Other (specify) ____________

Code B - Usage

1. Steam Production
2. Drying / Curing
3. Space Heating
4. Process Heat
5. Food Processing
6. Electrical Generation
7. Mechanical Work
8. Other (specify) ____________

***Pick only one option for a requested throughput.**

NOTE: Dryers, kilns, and furnaces also have to fill out Page 13.

STATIONARY INTERNAL COMBUSTION ENGINES:

Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Equipment Manufacturer, Type, and Model Number	Date of Manuf.	Date of Const.	Output Brake Horsepower (bhp)	Output Electrical Power (kW)	Type of Fuel	Usage* (use Code C)	Requested Throughput** (hrs/yr OR fuel/yr)	Federal Regulations that Apply
CT-01	Solar, Mars Turbine, 100-16000S		4/1/17	17,574	13,105	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98 NSPS Subpart KKKK
CT-02	Solar, Taurus Turbine, 70-10802S		4/1/17	11,882	8,860	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98 NSPS Subpart KKKK
CT-03	Solar, Taurus Turbine, 60-7800S		4/1/17	8,414	6,274	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98 NSPS Subpart KKKK
CT-04	Solar, Centaur Turbine, 50-6200LS		4/1/17	6,642	4,953	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98 NSPS Subpart KKKK
MT-01	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-02	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-03	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-04	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-05	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-06	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-07	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-08	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-09	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98
MT-10	Capstone, MicroTurbine, C200		4/1/17	268	200	Natural Gas	3	8,760 hrs/yr	40 CFR Part 98

[X] Estimated Emission Calculations Attached (include references of emission factors <u>and manufacturer specifications per engine</u>) and/or Stack Test Results if Available

Code C – Usage

1. Emergency Generator
2. Participates in Emergency Load Response Program
3. Non-Emergency Generator
4. Participates in Demand Response Program(s)
5. Other (specify) ______________________

***Can pick more than one option**
(i.e. 1 and 2 **OR** 3 and 4)

****Pick only one option for a requested throughput.**

LIQUID AND/OR SOLID WASTE INCINERATORS: (NOT AN AIR EMISSIONS CONTROL DEVICE)

Company Name:	Date:	Registration Number:

Unit Ref. No.	Equipment Manufacturer, Type, and Model Number	Date of Manuf.	Date of Const.	Incin. Max. Rated Capacity (lbs/hr)	Burner Rated Capacity (Btu/hr)		Minimum Chamber Temp. (^oF)		Requested Throughput to be Incinerated		Incin. Type (use Code D)	Waste Type (use Code E)	Min. Secondary Chamber Retention Time (sec)	Burn Down Cycle Time (hrs)	Federal Regulations that Apply
					Pri.	Sec.	Pri.	Sec.	Lbs/hr	Tons/yr					

☐ Estimated Emission Calculations Attached (include references of emission factors) and/or Stack Test Results if Available

Code D – Incinerator Type	**Code E – Waste Type**
1. Rotary Kiln 2. Mass Burn/Refuse Derived Fuel 3. Crematory 4. Single Chamber 5. Multiple Chamber 6. Other (specify) ____________	1. Paper Waste 2. Hospital Waste 3. Medical Waste 4. Municipal Waste 5. Animal Waste 6. Crematory Waste (Human Remains) 7. Industrial Waste 8. Other (specify) ____________

PROCESSING, MANUFACTURING, SURFACE COATING AND DEGREASING OPERATIONS:

Company Name:	Date:	Registration Number:

Unit Ref. No.	Process or Operation Name	Equipment Manufacturer, Type, and Model Number	Date of Manuf.	Date of Const.	Max. Rated Capacity (_____/hr)*	Requested Throughput*			Federal Regulations that Apply
						(_____/hr)	(_____/day)	(_____/yr)	

☐ Estimated Emission Calculations Attached (include references of emission factors) and/or Stack Test Results if Available

*** Specify units for each operation in tons, pounds, gallons, etc., as applicable. <u>For coating operations</u>, the maximum rated capacity is the spray gun capacity.**

INKS, COATINGS, STAINS, AND ADHESIVES:

Company Name:	Date:	Registration Number:

Unit Ref. No.	Coating Material (specify)	Coating Use (use Code F)	Lbs VOC in Coating as Applied			VOC Control Method (use Code G)	Solids Transfer Efficiency (%)	Coating Density as Applied (lbs/gal)	Maximum Coating Usage as Applied	
			Per gal coating	Per gal coating less water & exempt solvent	Per gal solids				(Gal/hr)	(Gal/yr)

Hazardous Air Pollutants (HAPs)	Lbs HAP/gal coating as applied	Hazardous Air Pollutants (HAPs)	Lbs HAP/gal coating as applied
CAS #: HAP Name:		CAS #: HAP Name:	
CAS #: HAP Name:		CAS #: HAP Name:	
CAS #: HAP Name:		CAS #: HAP Name:	

☐ Estimated Emission Calculations Attached (include references of emission factors <u>and MSDS or CPDS for each coating</u>)

Code F – Coating Use

1. Large Appliance Coatings
2. Magnet Wire Coatings
3. Auto and Light Duty Truck Coatings
   a. Prime Coat
   b. Guidecoat
   c. Topcoat
   d. Final Repair
   e. Anti-chip
   f. Anti-chip extreme performance
   g. Anti-chip visible surface
4. Aerospace Industries Coating
5. Magnetic Tape Coating
6. Can Coatings
   a. Base/Overvarnish
   b. Internal body/external ends
   c. 3-piece Can, side seam
   d. End seals
7. Metal Coil Coating
8. Non-Printing Paper/Fabric Coating
9. Publication Printing Inks and Coatings
10. Packaging Printing Inks and Coatings
11. Vinyl Coatings
12. Metal Furniture Coatings
13. Plastic Parts and Products Coatings
14. Miscellaneous Metal Parts Coatings
    a. Clear coatings
    b. Air-dried Coatings
    c. Extreme Performance Coatings
    d. Other coatings
15. Flatwood Paneling Coatings
    a. Printed Hardwood/Particleboard
    b. Natural finish Hardwood/Plywood
    c. Class II Hardboard
16. Paper and other Webs
17. Shipbuilding and Ship Repair Coating
18. Wood Furniture Coating
19. Flexographic Ink
20. Lithographic Ink
21. Rotogravure Ink
22. Adhesives – describe:__________ ____________________
23. Other:____________________

Code G – VOC Control Method

1. Low-VOC Coatings
   a. High-Solids Coatings
   b. Low-Solvent Coatings
   c. Waterborne Coatings
   d. Powder Coatings
   e. UV Light/Electron Beam Cured Coatings
   f. Electrodeposited Waterborne Coatings
2. Increased Solids Transfer Efficiency
3. Carbon Adsorption
4. Incineration
5. Regenerative Thermal Oxidizer (RTO)
6. Enclosures - Partial _______ % or Capture Efficiency ________ %
7. Other:____________________

<u>NOTE:</u> Fill out one page for each ink, coating, stain, and adhesive.

VOLATILE ORGANIC COMPOUND (VOC)/PETROLEUM LIQUID STORAGE TANKS:

Company Name: Atlantic Coast Pipeline, LLC	**Date:** 09/2015	**Registration Number:** NA

Unit Ref. No.	Tank Type (use Code H)	Source of Tank Contents (use Code I)	Date of Manuf.	Date of Const.	Material Stored - Name and CAS # (include Reid Vapor Pressure for Gasoline)	Max. True Vapor Pressure (psia)	Density* (lbs/gal)	Max. Average Storage Temp. (°F)	Tank Diameter (feet)	Tank Capacity (gal)	Requested Throughput (gal/yr)	Federal Regulations that Apply
TK-1	1b	5		4/1/17	Hydrocarbons (Produced Fluids)	5.6	6.67 (@ 100°F)	80	4.61	2,500	12,500	
TK-2	1b	5		4/1/17	Hydrocarbons (Lube Oil)	0.0001	7.51 (@ 20°C)	80	4.12	2,000	10,000	
TK-3	1b	3		4/1/17	Ammonia 7664-41-7			80	8.24	8,000	96,000	

[X] Estimated Emission Calculations Attached (include TANKS Program printouts)

Code H – Tank Type		**Code I – Source of Tank Contents**
1. Fixed Roof a. Vertical Tank b. Horizontal Tank 2. Floating Roof a. Internal (welded deck) b. Internal (bolted deck) – Specify Panel or Sheet c. External (welded deck) d. External (riveted deck)	3. Variable Vapor Space 4. Pressure Tank (over 15 psig) 5. Underground Splash Loading 6. Underground Submerged Loading 7. Underground Submerged Loading, Balanced 8. Other:____________	1. Pipeline 2. Rail Car 3. Tank Truck 4. Ship or Barge 5. Process

*** Specify the ASTM temperature standard at which the density was measured.**

VOLATILE ORGANIC COMPOUND (VOC)/PETROLEUM LIQUID STORAGE TANKS (CONTINUED):

Company Name:	Atlantic Coast Pipeline, LLC	**Date:**	09/2015	**Registration Number:**	NA

Unit Ref. No.	Tank Color		Fixed Roof Only					Floating Roof Only				
	Shell	Roof	Internal Tank Height or Length (feet)	Max. Hourly Filling (gallons)	External Fixed Roof			Seal Type (use Code J)	Max. Hourly Withdrawal (gallons)	Internal Floating Roof		
					Type of Roof (cone or dome)	Cone height (ft) and slope (ft/ft)	Dome height (ft) and radius (ft)			Self Supporting?	If no,	
											No. of Columns	Column Diameter (ft)
TK-1	Gray/ Light	Gray/ Light	20									
TK-2	Gray/ Light	Gray/ Light	20									
TK-3	Gray/ Light	Gray/ Light	20									

Code J – Seal Type (Pontoon External Only)

1. Mechanical Shoe
   a. Primary only
   b. Shoe mounted secondary
   c. Rim mounted secondary
2. Liquid Mounted
   a. Primary only
   b. Weather shield secondary
   c. Rim mounted secondary
3. Vapor Mounted
   a. Primary only
   b. Weather shield secondary
   c. Rim mounted secondary

(Double Deck External Only)

4. Mechanical Shoe
   a. Primary only
   b. Shoe mounted secondary
   c. Rim mounted secondary
5. Liquid Mounted
   a. Primary only
   b. Weather shield secondary
   c. Rim mounted secondary
6. Vapor Mounted
   a. Primary only
   b. Weather shield secondary
   c. Rim mounted secondary

(Internal Only)

7. Mechanical Shoe
   a. Primary only
   b. Shoe mounted secondary
   c. Rim mounted secondary
8. Liquid Mounted
   a. Primary only
   b. Rim mounted secondary
9. Vapor Mounted
   a. Primary only
   b. Rim mounted secondary

LOADING RACKS AND OIL-WATER SEPARATORS:

Company Name:	Date:	Registration Number:

Unit Ref. No.	Name of Product Loaded or Recovered	Max. Hourly Throughput (gallons)	Requested Annual Throughput (gallons)	Loading Racks Only		Oil-Water Separators Only	Federal Regulations that Apply
				Type of Loading (use Code K)	Hatch Vapor Closure on Loading Arms (use Code L)	Type of Enclosure (use Code M)	

☐ Estimated Emission Calculations Attached

Code K – Type of Loading	Code L – Hatch Vapor Closure	Code M – Type of Enclosure
1. Overhead Loading - splash fill, normal service 2. Overhead Loading - submerged fill, normal service 3. Bottom Loading - normal service 4. Overhead Loading - splash fill, balanced service 5. Overhead Loading - submerged fill, balanced service 6. Bottom Loading - Balanced service	1. None, open to air 2. Emco – Wheaton 3. OPW 4. Chiksan – LTV 5. Other:____________	1. Open 2. Partially Open 3. Floating Roof 4. Sealed Cover

FUMIGATION OPERATIONS:

Company Name:	Date:	Registration Number:

Unit Ref. No.	Object or Product to be Fumigated	Containment System	Fumigant	Max. Daily Fumigant Usage* (lbs/day or g/day)	Max. Annual Fumigant Usage* (lbs/yr or g/yr)	Estimated Number of Fumigation Events Per Year	Aeration Method	Distance from Fumigation Operation to Property or Fence Line (feet)

☐ Estimated Emission Calculations Attached

☐ Fumigation Operation is less than 300 feet to an area occupied by people

*** Specify units for each operation in pounds (methyl bromide) or grams (phosphine) per day or year.**

AIR POLLUTION CONTROL AND MONITORING EQUIPMENT:

Company Name: Atlantic Coast Pipeline, LLC	**Date:** 09/2015	**Registration Number:** NA

Unit Ref. No.	Vent/ Stack No.	Device Ref. No.	Pollutant/ Parameter	Air Pollution Control Equipment			Monitoring Instrumentation
				Manufacturer and Model No.	Type (use Code N)	Percent Efficiency (%)	Specify Type, Measured Pollutant, and Recorder Used
CT-01	**CT-01**	**SCR-01**	NOx	TBD	16	44.4	Combustion controls. Stack test for compliance demonstration
CT-01	**CT-01**	**OC-01**	CO VOC	TBD – Industry accepted reduction from oxidation catalyst	20	80 50	Combustion controls. Stack test for compliance demonstration
CT-02	**CT-02**	**SCR-02**	NOx	TBD	16	44.4	Combustion controls. Stack test for compliance demonstration
CT-02	**CT-02**	**OC-02**	CO VOC	TBD – Industry accepted reduction from oxidation catalyst	20	80 50	Combustion controls. Stack test for compliance demonstration
CT-03	**CT-03**	**SCR-03**	NOx	TBD	16	44.4	Combustion controls. Stack test for compliance demonstration
CT-03	**CT-03**	**OC-03**	CO VOC	TBD – Industry accepted reduction from oxidation catalyst	20	80 50	Combustion controls. Stack test for compliance demonstration
CT-04	**CT-04**	**SCR-04**	NOx	TBD	16	44.4	Combustion controls. Stack test for compliance demonstration
CT-04	**CT-04**	**OC-04**	CO VOC	TBD – Industry accepted reduction from oxidation catalyst	20	80 50	Combustion controls. Stack test for compliance demonstration

☐ Manufacturer Specifications Included

Code N – Type of Air Pollution Control Equipment

1. Settling Chamber
2. Cyclone
3. Multicyclone
4. Cyclone scrubber
5. Orifice scrubber
6. Mechanical scrubber
7. Venturi scrubber
   a. Fixed throat
   b. Variable throat
8. Mist eliminator
9. Filter
   a. Baghouse
   b. Other:____________________
10. Electrostatic Precipitator
   a. Hot side
   b. Cold side
   c. High voltage
   d. Low voltage
   e. Single stage
   f. Two stage
   g. Other:____________________
11. Catalytic Afterburner
12. Direct Flame Afterburner
13. Diesel Oxidation Catalyst (DOC)
14. Thermal Oxidizer
15. Regenerative Thermal Oxidizer (RTO)
16. Selective Catalytic Reduction (SCR)
17. Selective Non-Catalytic Reduction (SNCR)
17. Absorber
   a. Packed tower
   b. Spray tower
   c. Tray tower
   d. Venturi
   e. Other:____________________
18. Adsorber
   a. Activated carbon
   b. Molecular sieve
   c. Activated alumina
   d. Silica gel
   e. Other:____________________
19. Condenser (specify)
20. Other: Oxidation Catalyst (OxCat)

AIR POLLUTION CONTROL EQUIPMENT - SUPPLEMENTAL INFORMATION:

Company Name: Atlantic Coast Pipeline, LLC	**Date:** 09/2015	**Registration Number:** NA

Device Ref. No.	Type (use Code N)	Liquid Flow Rate (gpm) (4, 5, 6, 7, 17 ,19)	Liquid Medium (4, 5, 6, 7, 17, 19)	Cleaning Method (9, 10, 17, 18)	Number of Fields (10)	Number of Sections (9, 10)	Air to Cloth Ratio (fpm) (9)	Filter Material (9)	Inlet Temp. (°F)	Regeneration Method & Cycle Time (sec) (18)	Chamber Temp. (°F) (11, 12, 14, 15)	Retention Time (sec) (11, 12, 14, 15)	Pressure Drop (inch H_2O) (3, 4, 5, 6, 7, 9, 17)
SCR-01	16								925				
OC-01	20								750				
SCR-02	16								925				
OC-02	20								750				
SCR-03	16								925				
OC-03	20								750				
SCR-04	16								925				
OC-04	20								750				

NOTE: **Numbers listed in parenthesis in the columns above represent the Control Equipment in Code N below.**

Code N – Type of Air Pollution Control Equipment

1. Settling Chamber
2. Cyclone
3. Multicyclone
4. Cyclone scrubber
5. Orifice scrubber
6. Mechanical scrubber
7. Venturi scrubber
   a. Fixed throat
   b. Variable throat
8. Mist eliminator
9. Filter
   a. Baghouse
   b. Other:____________________
10. Electrostatic Precipitator
    a. Hot side
    b. Cold side
    c. High voltage
    d. Low voltage
    e. Single stage
    f. Two stage
    g. Other:____________________
11. Catalytic Afterburner
12. Direct Flame Afterburner
13. Diesel Oxidation Catalyst (DOC)
14. Thermal Oxidizer
15. Regenerative Thermal Oxidizer (RTO)
16. Selective Catalytic Reduction (SCR)
17. Selective Non-Catalytic Reduction (SNCR)
17. Absorber
    a. Packed tower
    b. Spray tower
    c. Tray tower
    d. Venturi
    e. Other:____________________
18. Adsorber
    a. Activated carbon
    b. Molecular sieve
    c. Activated alumina
    d. Silica gel
    e. Other:____________________
19. Condenser (specify)
20. Other: Oxidation Catalyst (OxCat)___

STACK PARAMETERS AND FUEL DATA:

Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Vent/ Stack No.	Vent/Stack or Exhaust Data						Fuel(s) Data				
		Vent/Stack Config. (use Code O)	Vent/Stack Height (feet)	Exit Diameter (feet)	Exit Gas Velocity (ft/sec)	Exit Gas Flow Rate (acfm)	Exit Gas Temp. (°F)	Type of Fuel	Heating Value (Btu/scf)	Max. Rated Burned/hr (Mscf/hr)	Max. Sulfur %	Max. Ash %
CT-01	CT-01	5	70	10.0	46.9	220,785	750	Natural Gas	1020	127.10	0.0005	0
CT-02	CT-02	5	70	7.5	56.0	148,553	750	Natural Gas	1020	85.56	0.0005	0
CT-03	CT-03	5	70	6.0	68.7	116,559	750	Natural Gas	1020	64.68	0.0005	0
CT-04	CT-04	5	70	6.0	58.0	98,384	750	Natural Gas	1020	54.03	0.0005	0
WH-01	WH-01	5	18	0.7	247.3	5,231	838	Natural Gas	1020	9.31	0.0005	0
LH-01	LH-01	5	23	1.9	16.7	2,957	982	Natural Gas	1020	16.67	0.0005	0
LH-02	LH-02	5	23	1.9	16.7	2,957	982	Natural Gas	1020	16.67	0.0005	0
LH-03	LH-03	5	23	1.9	16.7	2,957	982	Natural Gas	1020	16.67	0.0005	0
LH-04	LH-04	5	23	1.9	16.7	2,957	982	Natural Gas	1020	16.67	0.0005	0
MT-01	MT-01	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-02	MT-02	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-03	MT-03	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-04	MT-04	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-05	MT-05	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-06	MT-06	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-07	MT-07	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-08	MT-08	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-09	MT-09	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
MT-10	MT-10	5	25	2.5	8.9	2,621	535	Natural Gas	1020	2.24	0.0005	0
TK-1	TK-1	6	4.6				80	---	---	---	---	---
TK-2	TK-2	6	4.1				80	---	---	---	---	---
TK-3	TK-3	6	8.2				80	---	---	---	---	---

Code O – Vent/Stack Configuration

1. Stack discharging downward, or nearly download
2. Equivalent stack representing a combination of multiple actual stacks
3. Gooseneck stack
4. Stack discharging in a horizontal direction
5. Stack with an unobstructed opening discharge in a vertical direction
6. Vertical stack with a weather cap or similar obstruction in exhaust system

PROPOSED PERMIT LIMITS FOR CRITERIA POLLUTANTS:

Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Proposed Permit Limits for Criteria Pollutants															
	PM [a] (Particulate Matter)		PM-10 [a,b] (10 µM or smaller particulate matter)		PM 2.5 [a,b] (2.5 µM or smaller particulate matter)		SO_2 (Sulfur Dioxide)		NO_X (Nitrogen Oxides)		CO (Carbon Monoxide)		VOC [a] (Volatile Organic Compounds)		Pb (Lead)	
	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
CT-01	2.85	12.5	2.85	12.5	2.85	12.5	0.485	2.12	***	12.3	***	20.7	***	1.14	---	---
CT-02	1.92	8.41	1.92	8.41	1.92	8.41	0.326	1.43	***	8.35	***	13.1	***	0.775	---	---
CT-03	1.45	6.36	1.45	6.36	1.45	6.36	0.247	1.08	***	6.28	***	8.46	***	0.561	---	---
CT-04	1.20	5.26	1.20	5.26	1.20	5.26	0.204	0.894	***	5.20	***	8.19	***	0.477	---	---
WH-01	0.071	0.310	0.071	0.310	0.071	0.310	0.006	0.024	0.466	2.04	0.782	3.43	0.051	0.224	---	---
LH-01	0.119	0.521	0.119	0.521	0.119	0.521	0.010	0.044	0.187	0.819	0.629	2.76	0.102	0.447	---	---
LH-02	0.119	0.521	0.119	0.521	0.119	0.521	0.010	0.044	0.187	0.819	0.629	2.76	0.102	0.447	---	---
LH-03	0.119	0.521	0.119	0.521	0.119	0.521	0.010	0.044	0.187	0.819	0.629	2.76	0.102	0.447	---	---
LH-04	0.119	0.521	0.119	0.521	0.119	0.521	0.010	0.044	0.187	0.819	0.629	2.76	0.102	0.447	---	---
MT-01	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-02	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-03	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-04	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-05	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-06	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-07	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-08	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-09	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
MT-10	0.005	0.020	0.005	0.020	0.005	0.020	0.002	0.010	0.092	0.403	0.250	1.10	0.020	0.088	---	---
FUG-01	---	---	---	---	---	---	---	---	---	---	---	---	5.65	24.7	---	---
FUG-02	---	---	---	---	---	---	---	---	---	---	---	---	6.08	26.7	---	---
TK-1	---	---	---	---	---	---	---	---	---	---	---	---	0.080	0.350	---	---
TK-2	---	---	---	---	---	---	---	---	---	---	---	---	0.000	0.000	---	---
TOTAL:	**8.02**	**35.1**	**8.02**	**35.1**	**8.02**	**35.1**	**1.33**	**5.83**	***	**41.5**	***	**75.8**	***	**57.6**	**---**	**---**

*****Note: These NO_x, CO, and VOC lb/hr emission rates vary by operating scenario. Please see the permit application narrative for details.**

[X] Estimated Emission Calculations Attached (totals and per Unit Ref. No.)

[a] PM, PM-10, PM 2.5, and VOC should also be split up by component and reported under the Proposed Permit Limits for Toxic Pollutants/HAPs.
[b] PM-10 and PM 2.5 includes filterable and condensable.

PROPOSED PERMIT LIMITS FOR TOXIC POLLUTANTS/HAPS:

Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Proposed Permit Limits for Toxic/HAP Pollutants*															
	HAP Name: Formaldehyde CAS #: 50-00-0		HAP Name: Hexane CAS #: 110-54-3		HAP Name: CAS #:		HAP Name: CAS #:		HAP Name: CAS #:		HAP Name: CAS #:		HAP Name: CAS #:		HAP Name: CAS #:	
	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
CT-01	0.2	0.7	---	---												
CT-02	0.1	0.5	---	---												
CT-03	0.09	0.34	---	---												
CT-04	0.1	0.3	---	---												
WH-01	0.001	0.003	0.017	0.074												
LH-01	0.001	0.005	0.030	0.131												
LH-02	0.001	0.005	0.030	0.131												
LH-03	0.001	0.005	0.030	0.131												
LH-04	0.001	0.005	0.030	0.131												
MT-01	0.000	0.000	---	---												
MT-02	0.000	0.000	---	---												
MT-03	0.000	0.000	---	---												
MT-04	0.000	0.000	---	---												
MT-05	0.000	0.000	---	---												
MT-06	0.000	0.000	---	---												
MT-07	0.000	0.000	---	---												
MT-08	0.000	0.000	---	---												
MT-09	0.000	0.000	---	---												
MT-10	0.000	0.000	---	---												
FUG-01	---	---	0.320	1.40												
FUG-02	---	---	0.342	1.50												
TK-1	---	---	---	---												
TK-2	---	---	---	---												
TOTAL:	**0.495**	**1.86**	**0.799**	**3.50**												

[X] Estimated Emission Calculations Attached (totals and per Unit Ref. No.)

*** Specify the name of the toxic pollutant/HAP for each Unit Ref. No. along with the respective CAS Number**. Toxic Pollutant means a pollutant on the designated list in the Form 7 Instructions document. Particulate matter and volatile organic compounds are not toxic pollutants as generic classes of substances, but individual substances within these classes may be toxic pollutants because their toxic properties or because a TLV (tm) has been established.

PROPOSED PERMIT LIMITS FOR OTHER REGULATED POLLUTANTS:

Company Name:	Date:	Registration Number:

Unit Ref. No.	Proposed Permit Limits for Other Regulated Pollutants*															
	Pollutant Name:		Pollutant Name:		Pollutant Name:		Pollutant Name:		Pollutant Name:		Pollutant Name:		Pollutant Name:		Pollutant Name:	
	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
TOTAL:																

☐ Estimated Emission Calculations Attached (totals and per Unit Ref. No.)

* **Other Regulated Pollutant** include Fluorides, Sulfuric Acid Mist, Hydrogen Sulfide (H_2S), Total Reduced Sulfur (including H_2S), Reduced Sulfur Compounds (including H_2S), Municipal Waste Combustor Organics (measured as total tetra-through octa-chlorinated dibenzo-p-dioxins and dibenzofurans), Municipal Waste Combustor Metals (measured as particulate matter), Municipal Waste Combustor Acid Gases (measured as the sum of SO_2 and HCl), and Municipal Solid Waste Landfill Emissions (measured as nonmethane organic compounds).

PROPOSED PERMIT LIMITS FOR GREENHOUSE GASES (GHGs) ON MASS BASIS: FOR PSD MAJOR SOURCES ONLY

Company Name:	Date:	Registration Number:

Unit Ref. No.	Proposed Permit Limits for GHG Pollutants on Mass Basis													
	CO_2 (Carbon Dioxide)		N_2O (Nitrous Oxide)		CH_4 (Methane)		HFCs (Hydrofluoro-carbons)		PFCs (Perfluoro-carbons)		SF_6 (Sulfur Hexafluoride)		Total GHGs	
	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
TOTAL:														

☐ Estimated Emission Calculations Attached (totals and per Unit Ref. No.)

PROPOSED PERMIT LIMITS FOR GREENHOUSE GASES (GHGs) ON CO_2 EQUIVALENT EMISSIONS (CO_2e) BASIS: FOR PSD MAJOR SOURCES ONLY

Company Name:	Date:	Registration Number:

Unit Ref. No.	Proposed Permit Limits for GHG Pollutants on CO_2 Equivalent Basis													
	CO_2 (Carbon Dioxide)		N_2O (Nitrous Oxide)		CH_4 (Methane)		HFCs (Hydrofluoro-carbons)		PFCs (Perfluoro-carbons)		SF_6 (Sulfur Hexafluoride)		Total GHGs	
	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr	lbs/hr	tons/yr
TOTAL:														

☐ Estimated Emission Calculations Attached (totals and per Unit Ref. No.)

BASELINE ACTUAL EMISSIONS (BAE) FOR CRITERIA POLLUTANTS: FOR PSD OR MAJOR NONATTAINMENT SOURCES ONLY

Company Name:	Date:	Registration Number:

Unit Ref. No.	Average Actual Annual Emissions to the Atmosphere of Criteria Pollutants for the Period: __________, 20___ to __________, 20___							
	PM (Particulate Matter)	PM-10* (10 µM or smaller particulate matter)	PM 2.5* (2.5 µM or smaller particulate matter)	SO_2 (Sulfur Dioxide)	NO_X (Nitrogen Oxides)	CO (Carbon Monoxide)	VOC (Volatile Organic Compounds)	Pb (Lead)
	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr
TOTAL:								

☐ Background Documentation Attached (totals and per Unit Ref. No.)

*** PM-10 and PM 2.5 includes filterable and condensable.**

BASELINE ACTUAL EMISSIONS (BAE) FOR GREENHOUSE GASES (GHGs) POLLUTANT EMISSIONS ON MASS BASIS: <u>FOR PSD MAJOR SOURCES ONLY</u>

Company Name:	Date:	Registration Number:

Unit Ref. No.	Average Actual Annual Emissions to the Atmosphere of GHGs for the Period: __________, 20___ to __________, 20___					
	CO_2 (Carbon Dioxide)	N_2O (Nitrous Oxide)	CH_4 (Methane)	HFCs (Hydrofluorocarbons)	PFCs (Perfluorocarbons)	SF_6 (Sulfur Hexafluoride)
	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr
TOTAL:						

☐ Background Documentation Attached (totals and per Unit Ref. No.)

BASELINE ACTUAL EMISSIONS (BAE) FOR GREENHOUSE GASES (GHGs) POLLUTANT EMISSIONS ON CO_2 EQUIVALENT EMISSIONS (CO_2e) BASIS: FOR PSD MAJOR SOURCES ONLY

Company Name:	Date:	Registration Number:

Unit Ref. No.	Average Actual Annual Emissions to the Atmosphere of GHGs for the Period: _________, 20___ to _________, 20___					
	CO_2 (Carbon Dioxide)	N_2O (Nitrous Oxide)	CH_4 (Methane)	HFCs (Hydrofluorocarbons)	PFCs (Perfluorocarbons)	SF_6 (Sulfur Hexafluoride)
	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr	tons/yr
TOTAL:						

☐ Background Documentation Attached (totals and per Unit Ref. No.)

OPERATING PERIODS:

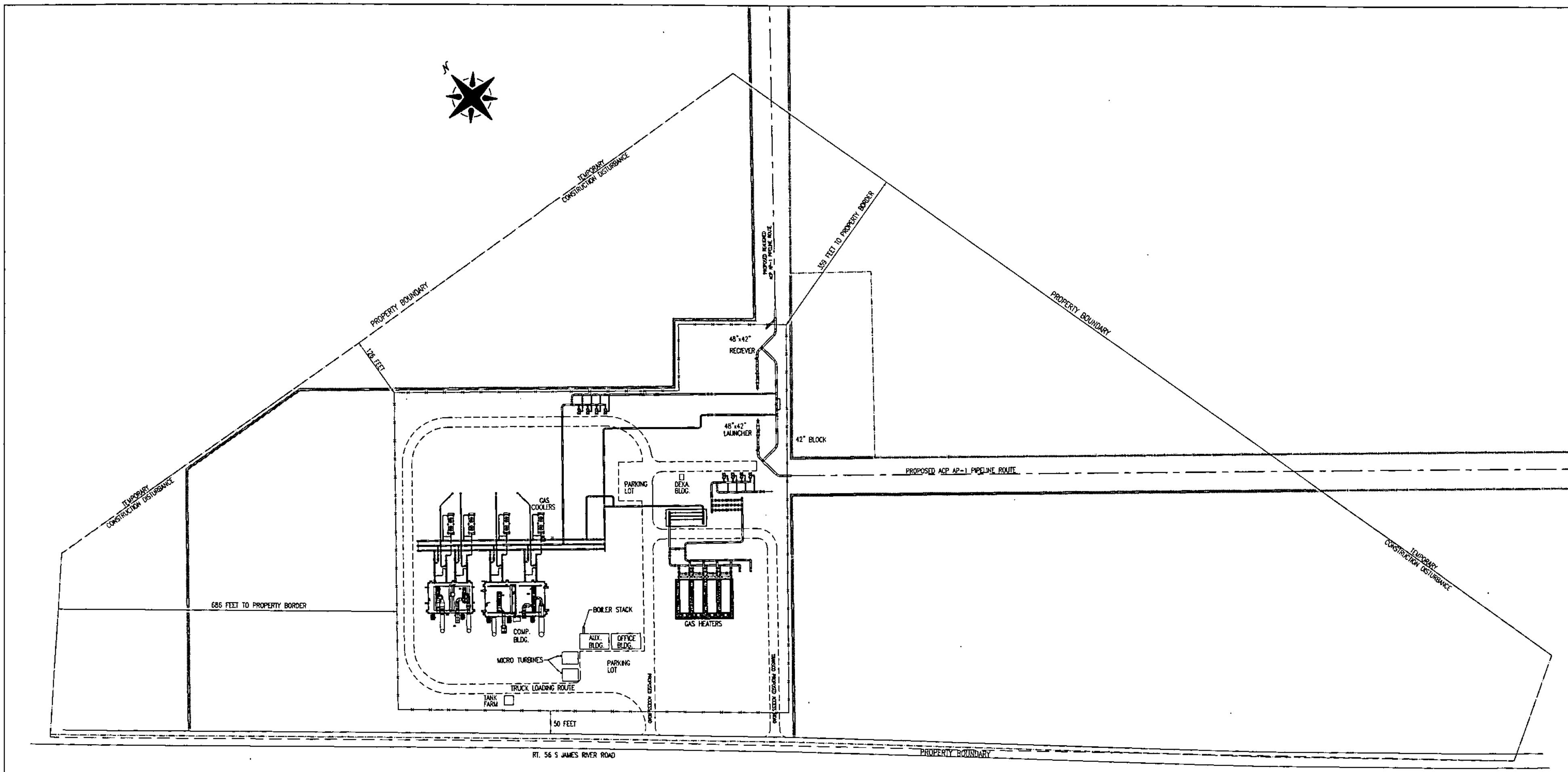
Company Name: Atlantic Coast Pipeline, LLC	Date: 09/2015	Registration Number: NA

Unit Ref. No.	Percent Annual Use/Throughput by Season				Normal Process/Equipment Operating Schedule			Maximum Process/Equipment Operating Schedule		
	December – February	March – May	June – August	September – November	Hours per Day	Days per Week	Weeks per Year	Hours per Day	Days per Week	Weeks per Year
CT-01	25	25	25	25	24	7	52	24	7	52
CT-02	25	25	25	25	24	7	52	24	7	52
CT-03	25	25	25	25	24	7	52	24	7	52
CT-04	25	25	25	25	24	7	52	24	7	52
WH-01	25	25	25	25	24	7	52	24	7	52
LH-01	25	25	25	25	24	7	52	24	7	52
LH-02	25	25	25	25	24	7	52	24	7	52
LH-03	25	25	25	25	24	7	52	24	7	52
LH-04	25	25	25	25	24	7	52	24	7	52
MT-01	25	25	25	25	24	7	52	24	7	52
MT-02	25	25	25	25	24	7	52	24	7	52
MT-03	25	25	25	25	24	7	52	24	7	52
MT-04	25	25	25	25	24	7	52	24	7	52
MT-05	25	25	25	25	24	7	52	24	7	52
MT-06	25	25	25	25	24	7	52	24	7	52
MT-07	25	25	25	25	24	7	52	24	7	52
MT-08	25	25	25	25	24	7	52	24	7	52
MT-09	25	25	25	25	24	7	52	24	7	52
MT-10	25	25	25	25	24	7	52	24	7	52
TK-1	25	25	25	25	24	7	52	24	7	52
TK-2	25	25	25	25	24	7	52	24	7	52
TK-3	25	25	25	25	24	7	52	24	7	52

Maximum Facility Operating Schedule		
Hours per Day	Days per Week	Weeks per Year
24	7	52

APPENDIX B

FACILITY PLOT PLAN



SITE LOCATION
LAT : 37°35'23.29"
LONG: 78°39'31.48"
MILE POST: 186.0 (APPROX)

GENERAL NOTES AND COMMENTS

ISSUED FOR REVIEW
7/10/15

80' 30' 0 80'
SCALE: 1" = 80'

LEGEND
- PROPOSED ACP PIPELINE
- TEMPORARY CONSTRUCTION DISTURBANCE
- PERMANENT MAINTAINED AREA
- PROPERTY BOUNDARY
- PROPOSED FENCE

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
J	7/10/15	RC	ISSUED FOR REVIEW		
I	7/7/15	RC	ALTERED ARRANGEMENT TO INCREASE EQUIPMENT DISTANCE FROM ROAD		
H	7/2/15	RC	ISSUED FOR CLIENT REVIEW		
G	6/29/15	RLR	CLIENT REVIEW		
F	6/25/15	RLR	REVISED PER DTI COMMENTS / ISSUED FOR REVIEW		
E	6/18/15	RC	REVISED PER DTI COMMENTS		
D	5/14/15	ARS	REVISED PER DTI COMMENTS		

SEAL

I3 Engineering and Consulting, LLC
INTEGRITY · INITIATIVE · INNOVATION

DRAWN:	ARS	12/10/15
CHECKED:	DLM	12/10/15
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	1" = 100'	

Atlantic Coast Pipeline, LLC
445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: WOODS CORNER M&R / BUCKINGHAM COMPRESSOR STATION PRELIMINARY SITE PLAN

DISTRICT:	COUNTY: BUCKINGHAM	STATE: VA	GROUP	DWG. NO.	REV.
DIR/FILE: DOM/Compressor Station/CS2 Rev H				2083A	J

APPENDIX C

POTENTIAL TO EMIT CALCULATIONS

Table C-1 Permit to Construct Application Project Equipment List
ACP Buckingham Compressor Station - Buckingham County, Virginia

Emission Point ID	Source	Manufacturer	Model/Type	Rated Capacity
CT-01	Compressor Turbine	Solar Turbines	Mars 100-16000S	17,574 hp
CT-02	Compressor Turbine	Solar Turbines	Taurus 70-10802S	11,882 hp
CT-03	Compressor Turbine	Solar Turbines	Taurus 60-7800S	8,414 hp
CT-04	Compressor Turbine	Solar Turbines	Centaur 50-6200LS	6,642 hp
WH-01	Boiler	TBD	TBD	9.5 MMBtu/hr
LH-01	Line Heater	ETI	WB HTR	17 MMBtu/hr
LH-02	Line Heater	ETI	WB HTR	17 MMBtu/hr
LH-03	Line Heater	ETI	WB HTR	17 MMBtu/hr
LH-04	Line Heater	ETI	WB HTR	17 MMBtu/hr
MT-01	Microturbine	Capstone	C200	200 kW
MT-02	Microturbine	Capstone	C200	200 kW
MT-03	Microturbine	Capstone	C200	200 kW
MT-04	Microturbine	Capstone	C200	200 kW
MT-05	Microturbine	Capstone	C200	200 kW
MT-06	Microturbine	Capstone	C200	200 kW
MT-07	Microturbine	Capstone	C200	200 kW
MT-08	Microturbine	Capstone	C200	200 kW
MT-09	Microturbine	Capstone	C200	200 kW
MT-10	Microturbine	Capstone	C200	200 kW
FUG-01	Fugitive Leaks - Blowdowns	-	-	-
FUG-02	Fugitive Leaks - Piping	-	-	-
TK-1	Accumulator Tank	-	-	2,500 gal
TK-2	Hydrocarbon (Waste Oil) Tank	--	--	2,000 gal
TK-3	Ammonia Tank	--	--	8,000 gal

Table C-2 Potential Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

Turbine Operational Parameters:

Normal Hours of Operation:	8,677
Hours at Low Load (<50%)	0
Hours of Low Temp. (< 0 deg. F	50
Hours of Start-up/Shut-down	33.3
Total Hours of Operation (hr/yr	8,760

Microturbine Operational Hours:

Normal Hours of Operation:	8,760

Boiler/Heater Operational Parameters:

Normal Hours of Operation:	8,760

Pre-Control Potential to Emit

Combustion Sources	Power Rating	Units	Fuel	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
				NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3	Total HAP
Solar Mars 100 Turbine	17,574	hp	Natural Gas	21.9	35.5	1.97	2.12	3.60	3.60	3.60	8.90	74,298	5.37	1.87	74,991	8.12	0.785
Solar Taurus 70 Turbine	11,882	hp	Natural Gas	14.9	23.8	1.36	1.43	2.42	2.42	2.42	5.99	49,980	3.62	1.26	50,446	5.77	0.525
Solar Taurus 60 Turbine	8,414	hp	Natural Gas	11.2	18.0	1.01	1.08	1.83	1.83	1.83	4.53	37,813	2.73	0.954	38,165	4.29	0.410
Solar Centaur 50L Turbine	6,642	hp	Natural Gas	9.25	14.8	0.834	0.894	1.51	1.51	1.51	3.74	31,295	2.26	0.788	31,587	3.58	0.352
Boiler	9.5	MMBtu/hr	Natural Gas	2.04	3.43	0.224	0.024	0.078	0.078	0.078	0.233	4,895	0.094	0.090	4924.38	0.00	0.077
M&R Heater 1 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812.06	0.00	0.138
M&R Heater 2 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812.06	0.00	0.138
M&R Heater 3 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812.06	0.00	0.138
M&R Heater 4 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812.06	0.00	0.138
MicroTurbine 1 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 2 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 3 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 4 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 5 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 6 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 7 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 8 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 9 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
MicroTurbine 10 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336.38	0.00	0.003
Total (tons/yr)				**67**	**117**	**8.07**	**5.83**	**9.9**	**9.9**	**9.9**	**25.19**	**246,636**	**15.6**	**5.70**	**248,725**	**21.8**	**2.73**

Turbine Control Efficiencies

Control Technology	NOx	CO	VOC
Selective Catalytic Reduction	44%	-	-
Oxidation Catalyst	-	80%	50%

Post-Control Potential to Emit

Combustion Sources	Power Rating	Units	Fuel	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
				NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3	Total HAP
Solar Mars 100 Turbine	17,574	hp	Natural Gas	12.1	7.1	0.99	2.12	3.60	3.60	3.60	8.90	74,298	5.37	1.87	74,991	8.12	0.785
Solar Taurus 70 Turbine	11,882	hp	Natural Gas	8.25	4.8	0.680	1.43	2.42	2.42	2.42	5.99	49,980	3.62	1.26	50,446	5.77	0.525
Solar Taurus 60 Turbine	8,414	hp	Natural Gas	6.23	3.6	0.505	1.08	1.83	1.83	1.83	4.53	37,813	2.73	0.954	38,165	4.29	0.410
Solar Centaur 50L Turbine	6,642	hp	Natural Gas	5.14	3.0	0.417	0.894	1.51	1.51	1.51	3.74	31,295	2.26	0.788	31,587	3.58	0.352
Boiler	9.5	MMBtu/hr	Natural Gas	2.04	3.43	0.224	0.024	0.078	0.078	0.078	0.233	4,895	0.094	0.090	4,924	0.00	0.077
M&R Heater 1 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.00	0.138
M&R Heater 2 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.00	0.138
M&R Heater 3 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.00	0.138
M&R Heater 4 (Woods Corner)	17	MMBtu/hr	Natural Gas	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8,812	0.00	0.138
MicroTurbine 1 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 2 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 3 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 4 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 5 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 6 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 7 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 8 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 9 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
MicroTurbine 10 (Woods Corner)	200	KW	Natural Gas	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1,336	0.00	0.003
Total (tons/yr)				**41.1**	**43.8**	**5.48**	**5.83**	**9.9**	**9.9**	**9.9**	**25.2**	**246,636**	**15.6**	**5.70**	**248,725**	**21.8**	**2.731**

Notes:

(1) Turbine emissions are calculated by the following formula: ER * Run Hours / 2000 * (1 - Control Efficiency)_
ER = Emission Rate for particular equipment and pollutant (lbs/hr)
2000 = the amount of lbs in a ton
(2) MicroTurbine emissions are calculated by the following formula: Power Rating * Run Hours * EF / 1000 / 2000_
Power Rating = Engine kW rating (kW)
EF = Emission Factor from either manufacturer's data or AP-42 (lb/MWh)
2000 = the amount of lbs in a ton
1000 = the amount of kW in a MW
(3) Boiler/Heater emissions calculated by the following formula: EF * Power Rating * Run Hours / HHV / 2000
EF = AP-42 Emission Factor (lb/MMSCF)
Power Rating = Boiler/Heater Heat Capacity (MMBtu/hr)
HHV = Natural Gas High Heating Value (1020 MMBtu/MMSCF)
(4) Turbines are equipped with Selective Catalytic Reduction (SCR) and oxidation catalyst for control of NOx (44%), CO (80%), and VOC (50%)
(5) Boiler assumed to have low-NOx burners
(6) See the "HAP Emissions" worksheet for a more detailed breakdown of HAP emissions
(7) See Emissions Factors table for Emissions Factors for each operating scenario.
(8) Each start-up/shut-down event assumed to last 10 minutes

Table C-3 Event Based Potential Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

Start-up Emissions

Combustion Sources	Power Rating	Units	Fuel	Start-up Events	Criteria Pollutants (tpy)			GHG Emissions (tpy)		
					NOx	CO	VOC	CO2	CH4	CO2e
Solar Mars 100 Turbine	17,574	hp	Natural Gas	100	0.070	6.18	0.071	41.5	0.284	48.6
Solar Taurus 70 Turbine	11,882	hp	Natural Gas	100	0.040	3.66	0.042	25.95	0.168	30.2
Solar Taurus 60 Turbine	8,414	hp	Natural Gas	100	0.035	3.22	0.037	20.50	0.148	24.20
Solar Centaur 50L Turbine	6,642	hp	Natural Gas	100	0.040	3.46	0.040	23.45	0.160	27.45
Total (tons/yr)					0.185	16.50	0.190	111.4	0.760	130.4

Shutdown Emissions

Combustion Sources	Power Rating	Units	Fuel	Shutdown Events	Criteria Pollutants (tpy)			GHG Emissions (tpy)		
					NOx	CO	VOC	CO2	CH4	CO2e
Solar Mars 100 Turbine	17,574	hp	Natural Gas	100	0.085	7.46	0.085	46.0	0.340	54.5
Solar Taurus 70 Turbine	11,882	hp	Natural Gas	100	0.055	4.67	0.053	28.8	0.212	34.1
Solar Taurus 60 Turbine	8,414	hp	Natural Gas	100	0.020	1.650	0.019	10.20	0.076	12.10
Solar Centaur 50L Turbine	6,642	hp	Natural Gas	100	0.020	1.770	0.020	10.85	0.080	12.85
Total (tons/yr)					0.180	15.55	0.177	95.8	0.708	113.5
Total SUSD Emissions (tons/yr)					0.365	32.1	0.367	207	1.468	244

Compressor Blowdown Emissions

Source Designation:	FUG-01

Blowdown Start-up Events

Blowdown from Start-up	38000	scf/event
Volumetric flow rate	385	scf-lbmol
Methane Molecular Weight	16	lb-lbmol
Methane Percent Weight	93%	%
Start-up Blowdown	1691	lb/event

Blowdown Shutdown Events

Blowdown from Shutdown	63000	scf/event
Volumetric flow rate	385	scf-lbmol
Methane Molecular Weight	16	lb-lbmol
Methane Percent Weight	93%	%
Shutdown Blowdown	2803	lb/event

Gas Composition

Pollutant	Molecular Weight (lb/lb-mol)	Molar (Volume) Fraction (mol%)	Wt. Fraction[1] (wt. %)
Total Stream Molecular Weight	16.89		
Non-VOC			
Carbon Dioxide	44.01	1.041%	2.71%
Nitrogen	28.01	0.994%	1.65%
Methane	16.04	94.21%	89.47%
Ethane	30.07	2.923%	5.20%
VOC			
Propane	44.10	0.546%	1.43%
n-Butane	58.12	0.084%	0.29%
IsoButane	58.12	0.079%	0.27%
n-Pentane	72.15	0.022%	0.09%
IsoPentane	72.15	0.024%	0.10%
n-Hexane	78.11	0.032%	0.15%
n-Heptane	100.21	0.049%	0.29%
Total VOC Fraction			2.62%
Total HAP Fraction			0.15%

Blowdown from Startup Events

Combustion Sources	Start-up Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
Solar Mars 100 Turbine	100	2.216	2.293	75.634	1,893	0.125
Solar Taurus 70 Turbine	100	2.216	2.293	75.634	1,893	0.125
Solar Taurus 60 Turbine	100	2.216	2.293	75.634	1,893	0.125
Solar Centaur 50L Turbine	100	2.216	2.293	75.634	1,893	0.125
Total (tons/yr)		8.866	9.173	303	7,573	0.500

Blowdown from Shutdown Events

Combustion Sources	Startup Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
Solar Mars 100 Turbine	100	3.675	3.80	125.39	3,139	0.207
Solar Taurus 70 Turbine	100	3.675	3.80	125.39	3,139	0.207
Solar Taurus 60 Turbine	100	3.675	3.80	125.39	3,139	0.207
Solar Centaur 50L Turbine	100	3.675	3.80	125.39	3,139	0.207
Total (tons/yr)		14.698	15.21	502	12,555	0.830

Site-Wide Blowdown Events

Site-Wide Blowdown	2,000,000	scf/event
Volumetric flow rate	385	scf-lbmol
Methane Molecular Weight	16	lb-lbmol
Methane Percent Weight	93%	%
Site-Wide Blowdown	88,990	lb/event

Blowdown from Site Wide Events

Combustion Sources	Startup Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
ACP-2	1	1.167	1.21	39.8	996	0.066
Total (tons/yr)		1.167	1.21	39.8	996	0.066
Total Blowdown Emissions (tons/yr)		24.73	25.6	844	21,124	1.396

Table C-4 Combustion Source Criteria Pollutant Emission Factors
ACP Buckingham Compressor Station - Buckingham County, Virginia

Solar Turbine Normal Operation Emission Factors (lb/hr)															
Equipment Name	Fuel	Units	NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3
Solar Centaur 50L Turbine	Natural Gas	lb/hr	1.98	3.30	0.190	0.20	0.35	0.35	0.35	0.85	7145	0.52	0.18	7212	0.818
Solar Taurus 60 Turbine	Natural Gas	lb/hr	2.40	4.00	0.230	0.25	0.42	0.42	0.42	1.03	8633	0.62	0.22	8713	0.979
Solar Taurus 70 Turbine	Natural Gas	lb/hr	3.18	5.30	0.310	0.33	0.55	0.55	0.55	1.37	11411	0.83	0.29	11517	1.317
Solar Mars 100 Turbine	Natural Gas	lb/hr	4.68	7.90	0.450	0.48	0.82	0.82	0.82	2.03	16963	1.23	0.43	17121	1.854
Solar Titan 130 Turbine	Natural Gas	lb/hr	5.70	9.60	0.550	0.59	1.00	1.00	1.00	2.46	20565	1.49	0.52	20757	2.33

Notes
(1) Pre-Control Emission Rates for NOx, CO, VOC, PMF, PMC, and CO2 taken from Solar Turbine Data at 100% load and 0 degrees F
(2) Emission Factors for SO2, CH4, N2O taken from AP-42 in (lbs/MMBtu) and multiplied by turbine fuel throughput by Solar Turbine at 100% load and 0 degree F to get Emission Rates
(3) Assume PMF=PMF-10=PMF-2.5; Filterable and Condensable based on Solar Turbine Emission Factor and ratio of AP-42 Table 3.1 factors
(4) NH3 emission rates based on a 10 ppm ammonia slip from the SCR based on manufacturer information
(5) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together
(6) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR Part 98]

Solar Turbine Alternate Operation Emission Factors (lb/hr)								
			< 0 degrees F			Solar Turbine Low Load F		
Equipment Name	Fuel	Units	NOx	CO	VOC	NOx	CO	VOC
Solar Centaur 50L Turbine	Natural Gas	lb/hr	26.4	19.8	0.380	15.4	1,320	7.60
Solar Taurus 60 Turbine	Natural Gas	lb/hr	32.0	24.0	0.460	18.7	1,600	9.20
Solar Taurus 70 Turbine	Natural Gas	lb/hr	42.4	31.8	0.620	24.7	2,120	12.4
Solar Mars 100 Turbine	Natural Gas	lb/hr	62.4	47.4	0.900	36.4	3,160	18.0

Notes
(1) Pre-Control low temperature Emission Rates for NOx, CO, VOC. Conservatively assume 120 ppm NOx, 150 ppm CO, and 5 ppm VOC (10% of UHC) per Table 2 of Solar PIL 167
(2) Pre-Control low load Emission Rates for NOx, CO, VOC. Conservatively assume 70 ppm NOx, 10,000 ppm CO, and 100 ppm VOC (10% of UHC) per Table 4 of Solar PIL 167

Solar Turbine Start-up and Shutdown Emission Factors (lb/event)														
			Start-up EFs						Shutdown Efs					
Equipment Name	Fuel	Units	NOx	CO	VOC	CO2	CH4	CO2e	NOx	CO	VOC	CO2	CH4	CO2e
Solar Centaur 50L Turbine	Natural Gas	lb/event	0.8	69.1	0.8	469	3.2	549	0.4	35.4	0.4	217	1.6	257
Solar Taurus 60 Turbine	Natural Gas	lb/event	0.7	64.3	0.7	410	3.0	484	0.4	33.0	0.4	204	1.5	242
Solar Taurus 70 Turbine	Natural Gas	lb/event	0.8	73.1	0.8	519	3.4	603	1.1	93.4	1.1	575	4.2	681
Solar Mars 100 Turbine	Natural Gas	lb/event	1.4	123.5	1.4	829	5.7	971	1.7	149.2	1.7	920	6.8	1090

Notes
(1) Start-up and Shutdown Emissions based on Solar Turbines Incorporated Product Information Letter 170: Emission Estimates at Start-up, Shutdown, and Commissioning for SoLoNOx Combustion Products (13 June 2012). Emission Estimates do not include SO2, PM, N2O, or any HAPs.
(2) VOCs assumed to be 20% of UHC and CH4 assumed to be 80% of UHC.
(3) CO2e emission rate calculated by multiplying each GHG (CO2, CH4) by its Global Warming Potential (GWP) and adding them together
(4) CO2 GWP = 1; CH4 GWP = 25; [40 CFR Part 98]

Engine and Boiler Emission Factors															
Equipment Type	Fuel	Units	NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3
Boiler < 100 MMBtu	Natural Gas	lb/MMscf	50	84	5.5	0.6	1.9	1.9	1.9	5.7	120000	2.3	2.2	120713	0.00
Space & Water Heaters	Natural Gas	lb/MMscf	100	84	5.5	0.6	1.9	1.9	1.9	5.7	120000	2.3	2.2	120713	0.00
M&R Line Heater	Natural Gas	lb/MMscf	11.22	37.74	6.12	0.6	1.44	1.44	1.44	5.7	120000	2.3	2.2	120713	0.00
Capstone Microturbine	Natural Gas	lb/MWh	0.460	1.250	0.100	0.012	0.006	0.006	0.006	0.016	1520	0.100	0.010	1526	0.00

Notes
(1) NOx, CO, VOC, and PMF-10 Emission Factors for Boilers < 100 MMBtu from ETI Combustion Analysis June 2015
(2) All other emission factors for natural gas boilers taken from AP-42 Tables 1.4-1 & 1.4-2
(3) Emission Factors for Space & Water Heaters taken from AP-42 Tables 1.4-1 & 1.4-2
(4) NOx, CO, VOC, CO2, and CH4 emission factors for Capstone Microturbine taken from Capstone Manufacturer data
(5) SO2, PMF, PMF-10, PMF-2.5, PMC, and N2O Emission factors for Capstone Turbines taken from AP-42 Table 3.1-2a and converted using 1 KWh = 3412 Btu
(6) NOx, CO, VOC, and PMF emission factors for Line Heaters from Manufacturer's data and convered to lb/MMscf using 1020 MMBtu/MMscf
(7) SO2, PMC, CO2, CH4, and N2O emission factors for Line Heaters from AP-42 Tables 1.4-1 & 1.4-2
(8) Assume PMF=PMF-10=PMF-2.5
(9) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together
(10) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR 98]

Table C-5 Hazardous Air Pollutant (HAP) Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

Annual HAP Emissions (lb/yr)										
Quantity @ ACP-2		1	1	1	1	1	1	1	4	10
Pollutant	HAP?	Solar Centaur 50L Turbine	Solar Taurus 60 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Boiler < 100 MMBtu	Boiler < 100 MMBtu	Boiler < 100 MMBtu	M&R Line Heater	Capstone Microturbine
1,1,2,2-Tetrachloroethane	Yes									
1,1,2-Trichloroethane	Yes									
1,1-Dichloroethane	Yes									
1,2,3-Trimethylbenzene	No									
1,2,4-Trimethylbenzene	No									
1,2-Dichloroethane	Yes									
1,2-Dichloropropane	Yes									
1,3,5-Trimethylbenzene	No									
1,3-Butadiene	Yes									0.003
1,3-Dichloropropene	Yes									
2,2,4-Trimethylpentane	Yes									
2-Methylnaphthalene	No					0.002	0.000	0.000	0.004	
3-Methylchloranthrene	No					0.000	0.000	0.000	0.000	
7,12-Dimethylbenz(a)anthracene	No					0.001	0.000	0.000	0.002	
Acenaphthene	No					0.000	0.000	0.000	0.000	
Acenaphthylene	No					0.000	0.000	0.000	0.000	
Acetaldehyde	Yes									0.239
Acrolein	Yes									0.038
Anthracene	No					0.000	0.000	0.000	0.000	
Benz(a)anthracene	No					0.000	0.000	0.000	0.000	
Benzene	Yes					0.171	0.009	0.004	0.307	0.072
Benzo(a)pyrene	No					0.000	0.000	0.000	0.000	
Benzo(b)fluoranthene	No					0.000	0.000	0.000	0.000	
Benzo(e)pyrene	No									
Benzo(g,h,i)perylene	No					0.000	0.000	0.000	0.000	
Benzo(k)fluoranthene	No					0.000	0.000	0.000	0.000	
Biphenyl	Yes									
Butane	No					171.335	9.018	3.607	306.600	
Butyr/Isobutyraldehyde	No									
Carbon Tetrachloride	Yes									
Chlorobenzene	Yes									
Chloroethane	Yes									
Chloroform	Yes									
Chrysene	No					0.000	0.000	0.000	0.000	
Cyclohexane	No									
Cyclopentane	No									
Dibenzo(a,h)anthracene	No					0.000	0.000	0.000	0.000	
Dichlorobenzene	Yes					0.098	0.005	0.002	0.175	
Ethane	No					252.924	13.312	5.325	452.600	
Ethylbenzene	Yes									0.191
Ethylene Dibromide	Yes									
Fluoranthene	No					0.000	0.000	0.000	0.000	
Fluorene	No					0.000	0.000	0.000	0.000	
Formaldehyde	Yes	664.779	773.647	992.029	1483.207	6.119	0.322	0.129	10.950	4.244
Hexane (or n-Hexane)	Yes					146.859	7.729	3.092	262.800	
Indeno(1,2,3-c,d)pyrene	No					0.000	0.000	0.000	0.000	
Isobutane	No									
Methanol	Yes									
Methylcyclohexane	No									
Methylene Chloride	Yes									
n-Nonane	No									
n-Octane	No									
Naphthalene	Yes					0.050	0.003	0.001	0.089	0.008
PAH	Yes									0.013
Pentane (or n-Pentane)	No					212.129	11.165	4.466	379.600	
Perylene	No									
Phenanthrene	No					0.001	0.000	0.000	0.002	
Phenol	Yes									
Propane	No					130.541	6.871	2.748	233.600	
Propylene Oxide	Yes									0.173
Pyrene	No					0.000	0.000	0.000	0.001	
Styrene	Yes									
Tetrachloroethane	No									
Toluene	Yes					0.277	0.015	0.006	0.496	0.777
Vinyl Chloride	Yes									
Xylene	Yes									0.383
Arsenic	Yes					0.016	0.001	0.000	0.029	
Barium	No					0.359	0.019	0.008	0.642	
Beryllium	Yes					0.001	0.000	0.000	0.002	
Cadmium	Yes					0.090	0.005	0.002	0.161	
Chromium	Yes					0.114	0.006	0.002	0.204	
Cobalt	Yes					0.007	0.000	0.000	0.012	
Copper	No					0.069	0.004	0.001	0.124	
Manganese	Yes					0.031	0.002	0.001	0.055	
Mercury	Yes					0.021	0.001	0.000	0.038	
Molybdenum	No					0.090	0.005	0.002	0.161	
Nickel	Yes					0.171	0.009	0.004	0.307	
Selenium	Yes					0.002	0.000	0.000	0.004	
Vanadium	No					0.188	0.010	0.004	0.336	
Zinc	No					2.366	0.125	0.050	4.234	
Lead	Yes					0.041	0.002	0.001	0.073	
Total HAPs		704.019	819.314	1050.586	1570.758					
Total HAP/unit (lb/yr)		**704**	**819**	**1051**	**1571**	**154**	**8.11**	**3.24**	**276**	**6.141**
Total HAP/unit (TPY)		**0.352**	**0.410**	**0.525**	**0.785**	**0.077**	**0.004**	**0.002**	**0.138**	**0.003**

Table C-5 Hazardous Air Pollutant (HAP) Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

		Annual HAP Emissions (lb/yr)								
Quantity @ ACP-2		1	1	1	1	1	1	1	4	10
Pollutant	HAP?	Solar Centaur 50L Turbine	Solar Taurus 60 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Boiler < 100 MMBtu	Boiler < 100 MMBtu	Boiler < 100 MMBtu	M&R Line Heater	Capstone Microturbine

Hazardous Air Pollutant

Notes:
(1) Emissions above are on a per unit basis
(2) Heat rates for Solar Turbines taken from Solar Datasheets
(3) Solar turbines have a 50% HAP control efficiency due to the Oxidation Catalyst

Table C-6 Combustion Source HAP Emission Factors

ACP Buckingham Compressor Station - Buckingham County, Virginia

Pollutant	HAP?	Emission Factors					
		Solar Centaur 50L Turbine	Solar Taurus 60 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Boiler/Line Heater < 100 MMBtu	Capstone Microturbine
		lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMscf	lb/kW-hr
1,1,2,2-Tetrachloroethane	Yes						
1,1,2-Trichloroethane	Yes						
1,1-Dichloroethane	Yes						
1,2,3-Trimethylbenzene	No						
1,2,4-Trimethylbenzene	No						
1,2-Dichloroethane	Yes						
1,2-Dichloropropane	Yes						
1,3,5-Trimethylbenzene	No						
1,3-Butadiene	Yes						1.5E-09
1,3-Dichloropropene	Yes						
2,2,4-Trimethylpentane	Yes						
2-Methylnaphthalene	No					2.4E-05	
3-Methylchloranthrene	No					1.8E-06	
7,12-Dimethylbenz(a)anthracene	No					1.6E-05	
Acenaphthene	No					1.8E-06	
Acenaphthylene	No					1.8E-06	
Acetaldehyde	Yes						1.4E-07
Acrolein	Yes						2.2E-08
Anthracene	No					2.4E-06	
Benz(a)anthracene	No					1.8E-06	
Benzene	Yes					2.1E-03	4.1E-08
Benzo(a)pyrene	No					1.2E-06	
Benzo(b)fluoranthene	No					1.8E-06	
Benzo(e)pyrene	No						
Benzo(g,h,i)perylene	No					1.2E-06	
Benzo(k)fluoranthene	No					1.8E-06	
Biphenyl	Yes						
Butane	No					2.1E+00	
Butyr/Isobutyraldehyde	No						
Carbon Tetrachloride	Yes						
Chlorobenzene	Yes						
Chloroethane	Yes						
Chloroform	Yes						
Chrysene	No					1.8E-06	
Cyclohexane	No						
Cyclopentane	No						
Dibenzo(a,h)anthracene	No					1.2E-06	
Dichlorobenzene	Yes					1.2E-03	
Ethane	No					3.1E+00	
Ethylbenzene	Yes						1.1E-07
Ethylene Dibromide	Yes						
Fluoranthene	No					3.0E-06	
Fluorene	No					2.8E-06	
Formaldehyde	Yes	2.9E-03	2.9E-03	2.9E-03	2.9E-03	7.5E-02	2.4E-06
Hexane (or n-Hexane)	Yes					1.8E+00	
Indeno(1,2,3-c,d)pyrene	No					1.8E-06	
Isobutane	No						
Methanol	Yes						
Methylcyclohexane	No						
Methylene Chloride	Yes						
n-Nonane	No						
n-Octane	No						
Naphthalene	Yes					6.1E-04	4.4E-09
PAH	Yes						7.5E-09
Pentane (or n-Pentane)	No					2.6E+00	
Perylene	No						
Phenanthrene	No					1.7E-05	
Phenol	Yes						
Propane	No					1.6E+00	
Propylene Oxide	Yes						9.9E-08
Pyrene	No					5.0E-06	
Styrene	Yes						
Tetrachloroethane	No						
Toluene	Yes					3.4E-03	4.4E-07
Vinyl Chloride+A32	Yes						
Xylene	Yes						2.2E-07
Arsenic	Yes					2.0E-04	

Table C-6 Combustion Source HAP Emission Factors
ACP Buckingham Compressor Station - Buckingham County, Virginia

Pollutant	HAP?	Emission Factors					
		Solar Centaur 50L Turbine	Solar Taurus 60 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Boiler/Line Heater < 100 MMBtu	Capstone Microturbine
		lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMscf	lb/kW-hr
Barium	No					4.4E-03	
Beryllium	Yes					1.2E-05	
Cadmium	Yes					1.1E-03	
Chromium	Yes					1.4E-03	
Cobalt	Yes					8.4E-05	
Copper	No					8.5E-04	
Manganese	Yes					3.8E-04	
Mercury	Yes					2.6E-04	
Molybdenum	No					1.1E-03	
Nickel	Yes					2.1E-03	
Selenium	Yes					2.4E-05	
Vanadium	No					2.3E-03	
Zinc	No					2.9E-02	
Lead	Yes					5.0E-04	
Total Haps		3.1E-03	3.1E-03	3.1E-03	3.1E-03		

Hazardous Air Pollutant

Notes:
(1) Emission factors for Solar and Capstone natural gas turbines from AP-42 Table 3.1-3
(2) Emission factors for natural gas boilers from AP-42 Tables 1.4-2, 1.4-3, and 1.4-4
(3) Emission factors for Solar natural gas turbines and Caterpillar natural gas emergency generators converted using 1 KWh = 3412 Btu and 1 kw = 1.341 hp
(4) Emission factors for Capstone natural gas turbines converted using 1 KWh = 3412 Btu
(5) Emission Factors (lb/MMBtu) for Formaldehyde and Total HAPs for Solar Turbines from Solar PIL 168

Table C-7 Potential Emissions From Fugitive Leaks

ACP Buckingham Compressor Station - Buckingham County, Virginia

Fugitive Emissions (FUG)

Source Designation:	FUG-02

Operational Parameters:

Annual Hours of Operation (hr/yr):	8,760

Compressor Fugitive Emissions Rate

Equipment	Service	CH4 Emission Factor[1]		CH_4 Weight Fraction[1]	Fug Emission Rate	
		ton/comp-hr			tpy	
Solar Turbine	Gas	2.67E-02		0.934	250	

1. Default methane basis and emission factor taken from Table 6-6 of Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Gas Industry, API, August 2009.
2. Sample calculations: Hours of operation (hr/yr) * EF (ton / compressor -hr) / Methane Fraction

Pipeline Natural Gas Fugitive Emissions

Equipment	Service	Emission Factor[1]	Source Count[2]	Total HC Potential Emissions		VOC Weight Fraction	VOC Emissions	CO_2 Weight Fraction	CO_2 Emissions	CH_4 Weight Fraction	CH_4 Emissions	HAP Weight Fraction	HAP Emissions
		lb/hr/source		lb/hr	tpy		tpy		tpy		tpy		tpy
Valves	Gas	4.50E-03	755	3.40	14.9	0.026	0.390	0.0271	0.404	0.895	13.3	1.48E-03	2.20E-02
Compressors	Gas	5.71E+01	4	228	1001	0.026	26.2	0.0271	27.1	0.895	895	1.48E-03	1.48E+00
Pump Seals	Gas	2.40E-03		0.00	0.00	0.026	0.00	0.0271	0.000	0.895	0.00	1.48E-03	0.00E+00
Others (compressors and others)	Gas	8.80E-03		0.00	0.00	0.026	0.00	0.0271	0.000	0.895	0.00	1.48E-03	0.00E+00
Connectors	Gas	2.00E-04	4	8.00E-04	3.50E-03	0.026	9.19E-05	0.0271	9.50E-05	0.895	0.00	1.48E-03	5.19E-06
Flanges	Gas	3.90E-04	509	0.199	0.869	0.026	0.023	0.0271	0.024	0.895	0.778	1.48E-03	1.29E-03
Open-ended lines	Gas	2.00E-03		0.000	0.000	0.026	0.00	0.0271	0.000	0.895	0.000	1.48E-03	0.00E+00
			Total	232.084	1016.529	-	26.7	-	27.6	-	909	-	1.50E+00

1. EPA Protocol for Equipment Leaks Emissions Estimate (EPA-453/R-95-017) Table 2-4: Oil and Gas Production Operations Emission Factors.
2. Component count based on Basic Systems Engineering Estimate.
3. Source count for fugitive emissions includes equipment from ACP-2 and the Woods Corner M&R station.

Sample Calculations:

Potential Emissions (lb/hr) = Emission Factor (lb/hr/source) * Source Count

Potential Emissions (tons/yr) = $(lb/hr)_{Potential}$ × Hours of Operation (hr/yr) × (1 ton/2,000 lb).

Table C-8 Tank Emissions

ACP Buckingham Compressor Station - Buckingham County, Virginia

Source Designation:	TK-1, TK-2, TK-3

Tank Parameters

Source	Type of Tank	Contents	Capacity (gal)	Throughput gal/yr	Tank Diam. ft	Tank Length ft	Paint Color	Paint Condition
TK-1	Horizontal, fixed	Produced Fluids	2,500	12,500	4.61	20	Light Grey	Good
TK-2	Horizontal, fixed	Lube Oil	2,000	10,000	4.12	10	Light Grey	Good

Total Emissions

Source	VOC Emissions							
	Flashing Losses		Working Losses		Breathing Losses		Total Losses	
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy
TK-1[1]	--	--	--	--	--	--	0.080	0.350
TK-2[2]	NA	NA	1.03E-06	4.50E-06	2.98E-06	1.31E-05	4.01E-06	1.76E-05

1. Losses were calculated for TK-1 using E&P Tanks Software. See attached for output.
2. Losses were calculated for TK-2 using EPA's TANKS 4.09d software with default breather vent settings.
3. Losses (Emissions) from TK-3 8,000-gallon Ammonia tank assumed to be insignficant.

Table C-9 Project Potential Emissions

ACP Buckingham Compressor Station - Buckingham County, Virginia

Combustion Sources	ID	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
		NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3	Total HAP
Solar Mars 100 Turbine	CT-01	12.3	20.7	1.14	2.12	3.60	3.60	3.60	8.90	74,385	6.00	1.87	75,094	8.12	0.785
Solar Taurus 70 Turbine	CT-02	8.35	13.08	0.775	1.43	2.42	2.42	2.42	5.99	50,035	4.00	1.26	50,511	5.77	0.525
Solar Taurus 60 Turbine	CT-03	6.28	8.46	0.561	1.08	1.83	1.83	1.83	4.53	37,843	2.96	0.954	38,201	4.29	0.410
Solar Centaur 50L Turbine	CT-04	5.20	8.19	0.477	0.894	1.51	1.51	1.51	3.74	31,329	2.50	0.788	31,627	3.58	0.352
Boiler	WH-01	2.04	3.43	0.224	0.024	0.078	0.078	0.078	0.233	4,895	0.094	0.090	4924	0.00	0.077
M&R Heater 1 (Woods Corner)	LH-01	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812	0.00	0.138
M&R Heater 2 (Woods Corner)	LH-02	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812	0.00	0.138
M&R Heater 3 (Woods Corner)	LH-03	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812	0.00	0.138
M&R Heater 4 (Woods Corner)	LH-04	0.819	2.76	0.447	0.044	0.105	0.105	0.105	0.416	8,760	0.168	0.161	8812	0.00	0.138
MicroTurbine 1 (Woods Corner)	MT-01	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 2 (Woods Corner)	MT-02	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 3 (Woods Corner)	MT-03	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 4 (Woods Corner)	MT-04	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 5 (Woods Corner)	MT-05	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 6 (Woods Corner)	MT-06	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 7 (Woods Corner)	MT-07	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 8 (Woods Corner)	MT-08	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 9 (Woods Corner)	MT-09	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
MicroTurbine 10 (Woods Corner)	MT-10	0.403	1.10	0.088	0.010	0.006	0.006	0.006	0.014	1,332	0.088	0.009	1336	0.00	0.00
Fugitive Leaks - Blowdowns	FUG-01	-	-	24.7	-	-	-	-	-	25.59	844		21124	-	1.396
Fugitive Leaks - Piping	FUG-02	-	-	26.7	-	-	-	-	-	27.6	909	-	22764	-	1.50
Accumulator Tank	TK-1	-	-	0.350	-	-	-	-	-	-	-	-	-	-	-
Hydrocarbon (Waste Oil) Tank	TK-2	-	-	1.76E-05	-	-	-	-	-	-	-	-	-	-	-
Total (tons/yr)		**41.5**	**75.8**	**57.6**	**5.83**	**9.92**	**9.92**	**9.92**	**25.2**	**246,897**	**1,770**	**5.70**	**292,856**	**21.8**	**5.63**

```
******************************************************************************************
*     Project Setup Information                                                          *
******************************************************************************************
Project File                : M:\Projects\D\Dominion\Atlantic Coastal Pipeline and Supply Header
Pipeline\Draft Rule 13 - APC1\Emission Calcs\TK-1 - Produced Fluids Tank.ept
Flowsheet Selection         : Oil Tank with Separator
Calculation Method          : AP42
Control Efficiency          : 100.0%
Known Separator Stream      : Low Pressure Gas
Entering Air Composition    : No

Date                        : 2015.07.13

******************************************************************************************
*     Data Input                                                                         *
******************************************************************************************

Separator Pressure          : 552.00[psig]
Separator Temperature       : 77.00[F]
Molar GOR                   : 0.0500
Ambient Pressure            : 14.70[psia]
Ambient Temperature         : 70.00[F]
C10+ SG                     : 0.8990
C10+ MW                     : 166.00

-- Low Pressure Gas ----------------------------------------------------------------------
   No.      Component              mol %
   1        H2S                    0.0000
   2        O2                     0.0000
   3        CO2                    1.0410
   4        N2                     0.9940
   5        C1                    94.2060
   6        C2                     2.9230
   7        C3                     0.5460
   8        i-C4                   0.0790
   9        n-C4                   0.0840
   10       i-C5                   0.0240
   11       n-C5                   0.0220
   12       C6                     0.0320
   13       C7+                    0.0490
   14       Benzene                0.0000
   15       Toluene                0.0000
   16       E-Benzene              0.0000
   17       Xylenes                0.0000
   18       n-C6                   0.0000
   19       224Trimethylp          0.0000
```

```
   C7+ Molar Ratio: C7  :     C8  :     C9  :     C10+
                    1.0000    1.0000    1.0000    1.0000

-- Sales Oil -------------------------------------------------------------------------
Production Rate           : 0.8[bbl/day]
Days of Annual Operation  : 365 [days/year]
API Gravity               : 46.0
Reid Vapor Pressure       : 7.70[psia]
Bulk Temperature          : 80.00[F]

-- Tank and Shell Data ---------------------------------------------------------------
Diameter                  : 5.08[ft]
Shell Height              : 11.90[ft]
Cone Roof Slope           : 0.06
Average Liquid Height     : 2.50[ft]
Vent Pressure Range       : 0.06[psi]
Solar Absorbance          : 0.54

-- Meteorological Data ---------------------------------------------------------------
Page  1------------------------------------------------------------------ E&P TANK
City                      : Charleston, WV
Ambient Pressure          : 14.70[psia]
Ambient Temperature       : 70.00[F]
Min Ambient Temperature   : 44.00[F]
Max Ambient Temperature   : 65.50[F]
Total Solar Insolation    : 1123.00[Btu/ft^2*day]


***************************************************************************************
*     Calculation Results                                                             *
***************************************************************************************

-- Emission Summary ------------------------------------------------------------------
Item                Uncontrolled   Uncontrolled
                    [ton/yr]       [lb/hr]
Total HAPs          0.010          0.002
Total HC            0.425          0.097
VOCs, C2+           0.383          0.087
VOCs, C3+           0.350          0.080

Uncontrolled Recovery Info.
       Vapor        21.2300 x1E-3  [MSCFD]
       HC Vapor     19.9800 x1E-3  [MSCFD]
       GOR          26.05          [SCF/bbl]

-- Emission Composition --------------------------------------------------------------
No  Component       Uncontrolled   Uncontrolled
```

		[ton/yr]	[lb/hr]
1	H2S	0.002	0.000
2	O2	0.000	0.000
3	CO2	0.022	0.005
4	N2	0.001	0.000
5	C1	0.043	0.010
6	C2	0.032	0.007
7	C3	0.083	0.019
8	i-C4	0.033	0.008
9	n-C4	0.102	0.023
10	i-C5	0.039	0.009
11	n-C5	0.047	0.011
12	C6	0.015	0.003
13	C7	0.014	0.003
14	C8	0.006	0.001
15	C9	0.001	0.000
16	C10+	0.000	0.000
17	Benzene	0.001	0.000
18	Toluene	0.000	0.000
19	E-Benzene	0.000	0.000
20	Xylenes	0.000	0.000
21	n-C6	0.010	0.002
22	224Trimethylp	0.000	0.000
	Total	0.451	0.103

-- Stream Data --

No.	Component	MW	LP Oil mol %	Flash Oil mol %	Sale Oil mol %	Flash Gas mol %	W&S Gas mol %	Total Emissions mol %
1	H2S	34.80	0.0508	0.0349	0.0030	0.6834	0.1835	0.5755
2	O2	32.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	CO2	44.01	0.2437	0.0907	0.0000	6.3467	0.0001	4.9770
4	N2	28.01	0.0102	0.0005	0.0000	0.3990	0.0001	0.3129
5	C1	16.04	0.9543	0.1475	0.0000	33.1362	0.0001	25.9849
6	C2	30.07	0.6701	0.3531	0.0000	13.3133	0.0001	10.4401
7	C3	44.10	2.1827	1.7648	0.4600	18.8508	16.8782	18.4251
8	i-C4	58.12	1.1269	1.0450	0.6191	4.3934	9.6293	5.5234
9	n-C4	58.12	4.6091	4.4100	3.1320	12.5490	33.6645	17.1061
10	i-C5	72.15	3.1066	3.0997	2.8099	3.3810	11.9899	5.2389
11	n-C5	72.15	5.0558	5.0823	4.8107	4.0000	14.9972	6.3734
12	C6	86.16	4.1726	4.2520	4.3657	1.0044	4.1822	1.6902
13	C7	100.20	10.3655	10.6043	11.1500	0.8388	3.6780	1.4516

No.	Component	MW	LP Oil mol %	Flash Oil mol %	Sale Oil mol %	Flash Gas mol %	W&S Gas mol %	Total Emissions mol %
14	C8	114.23	10.8426	11.1074	11.7774	0.2806	1.2761	0.4954
15	C9	128.28	5.5127	5.6497	6.0063	0.0497	0.2328	0.0892
16	C10+	166.00	45.9695	47.1217	50.1681	0.0099	0.0486	0.0182
17	Benzene	78.11	0.5685	0.5808	0.6057	0.0778	0.3297	0.1322
18	Toluene	92.13	0.2132	0.2183	0.2311	0.0082	0.0362	0.0142
19	E-Benzene	106.17	0.0711	0.0729	0.0774	0.0009	0.0041	0.0016

20	Xylenes	106.17	0.6802	0.6971	0.7408	0.0075	0.0344	0.0133
21	n-C6	86.18	3.5939	3.6672	3.7955	0.6694	2.8351	1.1368
22	224Trimethylp	114.24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	MW		123.89	126.03	129.50	38.64	63.78	44.07
	Stream Mole Ratio		1.0000	0.9755	0.9688	0.0245	0.0067	0.0312
	Heating Value	[BTU/SCF]				2044.13	3547.91	2368.67
	Gas Gravity	[Gas/Air]				1.33	2.20	1.52
	Bubble Pt. @ 100F	[psia]	56.28	19.66	6.19			
	RVP @ 100F	[psia]	126.75	78.89	38.81			
	Spec. Gravity @ 100F		0.800	0.803	0.810			

TANKS 4.0.9d
Emissions Report - Detail Format
Tank Indentification and Physical Characteristics

Identification	
User Identification:	TK-2
City:	
State:	West Virginia
Company:	
Type of Tank:	Horizontal Tank
Description:	Used Oil Aboveground Storage Tank
Tank Dimensions	
Shell Length (ft):	20.06
Diameter (ft):	4.12
Volume (gallons):	2,000.00
Turnovers:	5.00
Net Throughput(gal/yr):	10,000.00
Is Tank Heated (y/n):	N
Is Tank Underground (y/n):	N
Paint Characteristics	
Shell Color/Shade:	Gray/Light
Shell Condition	Good
Breather Vent Settings	
Vacuum Settings (psig):	-0.03
Pressure Settings (psig)	0.03

Meterological Data used in Emissions Calculations: Charleston, West Virginia (Avg Atmospheric Pressure = 14.25 psia)

TANKS 4.0.9d
Emissions Report - Detail Format
Liquid Contents of Storage Tank

TK-2 - Horizontal Tank

Mixture/Component	Month	Daily Liquid Surf. Temperature (deg F) Avg.	Min.	Max.	Liquid Bulk Temp (deg F)	Vapor Pressure (psia) Avg.	Min.	Max.	Vapor Mol. Weight.	Liquid Mass Fract.	Vapor Mass Fract.	Mol. Weight	Basis for Vapor Pressure Calculations
Used Oil	All	61.57	52.97	70.18	57.22	0.0001	0.0001	0.0001	380.0000			200.00	

TANKS 4.0.9d
Emissions Report - Detail Format
Detail Calculations (AP-42)

TK-2 - Horizontal Tank

Annual Emission Calcaulations	
Standing Losses (lb):	0.0261
Vapor Space Volume (cu ft):	170.3396
Vapor Density (lb/cu ft):	0.0000
Vapor Space Expansion Factor:	0.0618
Vented Vapor Saturation Factor:	1.0000
Tank Vapor Space Volume:	
Vapor Space Volume (cu ft):	170.3396
Tank Diameter (ft):	4.1200
Effective Diameter (ft):	10.2608
Vapor Space Outage (ft):	2.0600
Tank Shell Length (ft):	20.0600
Vapor Density	
Vapor Density (lb/cu ft):	0.0000
Vapor Molecular Weight (lb/lb-mole):	380.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0001
Daily Avg. Liquid Surface Temp. (deg. R):	521.2427
Daily Average Ambient Temp. (deg. F):	54.9833
Ideal Gas Constant R (psia cuft / (lb-mol-deg R)):	10.731
Liquid Bulk Temperature (deg. R):	516.8933
Tank Paint Solar Absorptance (Shell):	0.5400
Daily Total Solar Insulation Factor (Btu/sqft day):	1,250.5726
Vapor Space Expansion Factor	
Vapor Space Expansion Factor:	0.0618
Daily Vapor Temperature Range (deg. R):	34.4127
Daily Vapor Pressure Range (psia):	0.0000
Breather Vent Press. Setting Range(psia):	0.0600
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0001
Vapor Pressure at Daily Minimum Liquid Surface Temperature (psia):	0.0001
Vapor Pressure at Daily Maximum Liquid Surface Temperature (psia):	0.0001
Daily Avg. Liquid Surface Temp. (deg R):	521.2427
Daily Min. Liquid Surface Temp. (deg R):	512.6395
Daily Max. Liquid Surface Temp. (deg R):	529.8458
Daily Ambient Temp. Range (deg. R):	21.5333
Vented Vapor Saturation Factor	
Vented Vapor Saturation Factor:	1.0000
Vapor Pressure at Daily Average Liquid: Surface Temperature (psia):	0.0001
Vapor Space Outage (ft):	2.0600
Working Losses (lb):	0.0090
Vapor Molecular Weight (lb/lb-mole):	380.0000
Vapor Pressure at Daily Average Liquid Surface Temperature (psia):	0.0001
Annual Net Throughput (gal/yr.):	10,000.0000
Annual Turnovers:	5.0000
Turnover Factor:	1.0000
Tank Diameter (ft):	4.1200
Working Loss Product Factor:	1.0000
Total Losses (lb):	0.0352

TANKS 4.0.9d
Emissions Report - Detail Format
Individual Tank Emission Totals

Emissions Report for: Annual

TK-2 - Horizontal Tank

	Losses(lbs)		
Components	Working Loss	Breathing Loss	Total Emissions
Used Oil	0.01	0.03	0.04

APPENDIX D

VENDOR SPECIFICATIONS

Solar Turbines Emissions Estimates

Mars 100-16000S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	8787	73.11	30.58	9	2.6	25	4.4	25	2.5	2.5	0.3	9609	0.02	1.6	650	298,129
59	7760	85.24	23.16	9	3.1	25	5.2	25	3	2.5	0.3	11107	0.02	1.9	949	275,560
100	6580	75.95	22.05	9	2.7	25	4.5	25	2.6	2.5	0.3	9713	0.02	1.7	1009	240842

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	13180	115.67	28.99	9	4.2	25	7.1	25	4.0	2.5	0.4	15149	0.02	2.5	870	355,319
59	11640	101.99	29.04	9	3.7	25	6.2	25	3.5	2.5	0.4	13280	0.02	2.2	916	310,038
100	9870	90.11	27.87	9	3.2	25	5.4	25	3.1	2.5	0.3	11519	0.02	2.0	965	271481

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	17574	129.64	34.49	9	4.7	25	7.9	25	4.5	2.5	0.5	16963	0.02	2.9	864	366,922
59	15519	116.41	33.92	9	4.2	25	8.6	25	4.9	2.5	0.5	15148	0.02	2.6	908	334,207
100	13160	104.09	32.17	9	3.7	25	6.2	25	3.6	2.5	0.4	13299	0.02	2.3	945	298619

Solar Turbines Emissions Estimates

Taurus 70-10802S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	5941	63.54	23.79	9	2.3	25	3.9	25	2.2	2.5	0.2	8321	0.02	1.4	910	199,373
59	5430	56.92	24.27	9	2.0	25	3.4	25	2.0	2.5	0.2	7407	0.02	1.3	991	170,275
100	4341	49.58	22.28	9	1.7	25	3.0	25	1.7	2.5	0.2	6336	0.02	1.1	1045	149576

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	8912	76.91	29.49	9	2.8	25	4.7	25	2.7	2.5	0.3	10063	0.02	1.7	898	224,735
59	8145	68.47	30.27	9	2.5	25	4.2	25	2.4	2.5	0.2	8905	0.02	1.5	957	194,658
100	6512	59.08	28.05	9	2.1	25	3.5	25	2.0	2.5	0.2	7544	0.02	1.3	1019	165855

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	11882	87.27	34.64	9	3.2	25	5.3	25	3.1	2.5	0.3	11411	0.02	1.9	864	366,922
59	10860	79.24	34.87	9	2.8	25	4.8	25	2.8	2.5	0.3	10301	0.02	1.7	908	334,207
100	8683	68.40	32.30	9	2.4	25	4.1	25	2.3	2.5	0.2	8730	0.02	1.5	945	298619

Solar Turbines Emissions Estimates

Taurus 60-7800S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	4207	49.41	21.67	9	1.8	25	3.0	25	1.7	2.5	0.2	6478	0.02	1.1	876	166,972
59	3750	44.11	21.63	9	1.6	25	2.7	25	1.5	2.5	0.2	5748	0.02	1.0	950	144,301
100	3121	39.61	20.05	9	1.4	25	2.4	25	1.4	2.5	0.1	5067	0.02	0.9	999	128111

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	6311	58.62	27.39	9	2.1	25	3.6	25	2.1	2.5	0.2	7678	0.02	1.3	883	180,945
59	5625	51.92	27.56	9	1.9	25	3.2	25	1.8	2.5	0.2	6761	0.02	1.1	937	158,403
100	4682	46.07	25.86	9	1.6	25	2.7	25	1.6	2.5	0.2	5889	0.02	1.0	984	139855

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	8414	65.97	32.45	9	2.4	25	4.0	25	2.3	2.5	0.2	8633	0.02	1.5	889	186,881
59	7500	60.58	31.5	9	2.2	25	3.7	25	2.1	2.5	0.2	7881	0.02	1.3	956	169,979
100	6242	53.78	29.53	9	1.9	25	3.2	25	1.8	2.5	0.2	6870	0.02	1.2	999	151663

Solar Turbines Emissions Estimates

Centaur 50-6200LS

Assumptions: pipeline natural gas, 150' elevation, 5"/8" inlet/outlet losses, nominal performance

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO_2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
50% load																
0	3321	39.27	21.54	9	1.4	25	2.4	25	1.4	2.5	0.1	5155	0.02	0.9	837	139,384
59	3006	35.20	21.73	9	1.3	25	2.1	25	1.2	2.5	0.1	4591	0.02	0.8	915	119,683
100	2426	30.76	20.06	9	1.1	25	1.8	25	1.0	2.5	0.1	3938	0.02	0.7	966	103305
75% load																
Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO_2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	4981	47.21	26.85	9	1.7	25	2.9	25	1.6	2.5	0.2	6189	0.02	1.0	849	152,889
59	4509	42.05	27.29	9	1.5	25	2.5	25	1.5	2.5	0.2	5479	0.02	0.9	908	133,124
100	3639	36.70	25.23	9	1.3	25	2.2	25	1.2	2.5	0.1	4695	0.02	0.8	959	115664
100% load																
Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO_2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	6642	54.55	30.98	9	2.0	25	3.3	25	1.9	2.5	0.2	7145	0.02	1.2	871	161,184
59	6012	50.72	30.16	9	1.8	25	3.1	25	1.7	2.5	0.2	6603	0.02	1.1	956	144,840
100	4852	44.43	27.78	9	1.6	25	2.6	25	1.5	2.5	0.2	5679	0.02	1.0	1004	127484

SoLoNOx Products: Emissions in Non-SoLoNOx Modes

Leslie Witherspoon
Solar Turbines Incorporated

PURPOSE

Solar's gas turbine dry low NOx emissions combustion systems, known as *SoLoNOx*™, have been developed to provide the lowest emissions possible during normal operating conditions. In order to optimize the performance of the turbine, the combustion and fuel systems are designed to reduce NOx, CO and unburned hydrocarbons (UHC) without penalizing stability or transient capabilities. At very low load and cold temperature extremes, the *SoLoNOx* system must be controlled differently in order to assure stable operation. The required adjustments to the turbine controls at these conditions cause emissions to increase.

The purpose of this Product Information Letter is to provide emissions estimates, and in some cases warrantable emissions for NOx, CO and UHC, at off-design conditions.

Historically, regulatory agencies have not required a specific emissions level to be met at low load or cold ambient operating conditions, but have asked what emissions levels are expected. The expected values are necessary to appropriately estimate emissions for annual emissions inventory purposes and for New Source Review applicability determinations and permitting.

COLD AMBIENT EMISSIONS ESTIMATES

Solar's standard temperature range warranty for gas turbines with *SoLoNOx* combustion is ≥ 0°F (–20°C). The *Titan*™ 250 is an exception, with a lower standard warranty at ≥ –20°F (–29°C). At ambient temperatures below 0°F, many of Solar's turbine engine models are controlled to increase pilot fuel to improve flame stability and emissions are higher. Without the increase in pilot fuel at temperatures below 0°F the engines may exhibit combustor rumble, as operation may be near the lean stability limit.

If a cold ambient emissions warranty is requested, a new production turbine configured with the latest combustion hardware is required. For most models this refers to the inclusion of Cold Ambient Fuel Control Logic.

Emissions warranties are not offered for ambient temperatures below –20°F (–29°C). In addition, cold ambient emissions warranties cannot be offered for the *Centaur*® 40 turbine.

Table 1 provides expected and warrantable (upon Solar's documented approval) emissions levels for Solar's *SoLoNOx* combustion turbines. All emissions levels are in ppm at 15% O_2. Refer to Product Information Letter 205 for *Mercury*™ 50 turbine emissions estimates.

For information on the availability and approvals for cold ambient temperature emissions warranties, please contact Solar's sales representatives.

Table 2 summarizes "expected" emissions levels for ambient temperatures below 0°F (–20°C) for Solar's *SoLoNOx* turbines that do not have current production hardware or for new production hardware that is not equipped with the cold ambient fuel control logic. The emissions levels are extrapolated from San Diego factory tests and may vary at extreme temperatures and as a result of variations in other parameters, such as fuel composition, fuel quality, etc.

For more conservative NOx emissions estimate for new equipment, customers can refer to the New Source Performance Standard (NSPS) 40CFR60, subpart KKKK, where the allowable NOx emissions level for ambient temperatures < 0°F (–20°F) is 150 ppm NOx at 15% O_2. For pre-February 18, 2005, *SoLoNOx* combustion turbines subject to 40CFR60 subpart GG, a conservative estimate is the appropriate subpart GG emissions level. Subpart GG levels range from 150 to 214 ppm NOx at 15% O_2 depending on the turbine model.

Table 3 summarizes emissions levels for ambient temperatures below –20°F (–29°C) for the *Titan* 250.

Table 1. Warrantable Emissions Between 0°F and –20°F (–20° to –29°C) for New Production

Turbine Model	Fuel System	Fuel	Applicable Load	NOx, ppm	CO, ppm	UHC, ppm
Centaur 50	Gas Only	Gas	50 to 100% load	42	100	50
	Dual Fuel	Gas	50 to 100% load	72	100	50
Taurus™ 60	Gas Only or Dual Fuel	Gas	50 to 100% load	42	100	50
Taurus 65	Gas Only	Gas	50 to 100% load	42	100	50
Taurus 70	Gas Only or Dual Fuel	Gas	50 to 100% load	42	100	50
Mars® 90	Gas Only	Gas	50 to 100% load	42	100	50
Mars 100	Gas Only or Dual Fuel	Gas	50 to 100% load	42	100	50
Titan 130	Gas Only or Dual Fuel	Gas	50 to 100% load	42	100	50
Titan 250	Gas Only	Gas	40 to 100% load	25	50	25
	Gas Only	Gas	40 to 100% load	15	25	25
Centaur 50	Dual Fuel	Liquid	65 to 100% load	120	150	75
Taurus 60	Dual Fuel	Liquid	65 to 100% load	120	150	75
Taurus 70	Dual Fuel	Liquid	65 to 100% load	120	150	75
Mars 100	Dual Fuel	Liquid	65 to 100% load	120	150	75
Titan 130	Dual Fuel	Liquid	65 to 100% load	120	150	75

Table 2. Expected Emissions below 0°F (–20°C) for SoLoNOx Combustion Turbines

Turbine Model	Fuel System	Fuel	Applicable Load	NOx, ppm	CO, ppm	UHC, ppm
Centaur 40	Gas Only or Dual Fuel	Gas	80 to 100% load	120	150	50
Centaur 50	Gas Only	Gas	50 to 100% load	120	150	50
	Dual Fuel	Gas	50 to 100% load	120	150	50
Taurus 60	Gas Only or Dual Fuel	Gas	50 to 100% load	120	150	50
Taurus 65	Gas Only	Gas	50 to 100% load	120	150	50
Taurus 70	Gas Only or Dual Fuel	Gas	50 to 100% load	120	150	50
Mars 90	Gas Only	Gas	80 to 100% load	120	150	50
Mars 100	Gas Only or Dual Fuel	Gas	50 to 100% load	120	150	50
Titan 130	Gas Only or Dual Fuel	Gas	50 to 100% load	120	150	50
Centaur 40	Dual Fuel	Liquid	80 to 100% load	120	150	75
Centaur 50	Dual Fuel	Liquid	65 to 100% load	120	150	75
Taurus 60	Dual Fuel	Liquid	65 to 100% load	120	150	75
Taurus 70	Dual Fuel	Liquid	65 to 100% load	120	150	75
Mars 100	Dual Fuel	Liquid	65 to 100% load	120	150	75
Titan 130	Dual Fuel	Liquid	65 to 100% load	120	150	75

Table 3. Expected Emissions below –20°F (–29°C) for the Titan 250 SoLoNOx Combustion Turbine

Turbine Model	Fuel System	Fuel	Applicable Load	NOx, ppm	CO, ppm	UHC, ppm
Titan 250	Gas Only	Gas	40 to 100% load	70	150	50

COLD AMBIENT PERMITTING STRATEGY

There are several permitting options to consider when permitting in cold ambient climates. Customers can use a tiered permitting approach or choose to permit a single emission rate over all temperatures. Historically, most construction and operating permits were silent on the ambient temperature boundaries for *SoLoNOx* operation.

Some customers have used a tiered permitting strategy. For purposes of compliance and annual emissions inventories, a digital thermometer is installed to record ambient temperature. The amount of time is recorded that the ambient temperature falls below 0°F. The amount of time below 0°F is then used with the emissions estimates shown in Tables 1 and 2 to estimate "actual" emissions during sub-zero operation.

A conservative alternative to using the NOx values in Tables 1, 2 and 3 is to reference 40CFR60 subpart KKKK, which allows 150 ppm NOx at 15% O_2 for sub-zero operation.

For customers who wish to permit at a single emission rate over all ambient temperatures, inlet air heating can be used to raise the engine inlet air temperature (T_1) above 0°F. With inlet air heating to keep T_1 above 0°F, standard emission warranty levels may be offered.

Inlet air heating technology options include an electric resistance heater, an inlet air to exhaust heat exchanger and a glycol heat exchanger.

If an emissions warranty is desired and ambient temperatures are commonly below –20°F (–29°C), inlet air heating can be used to raise the turbine inlet temperature (T_1) to at least –20°F. In such cases, the values shown in Table 1 can be warranted for new production.

EMISSIONS ESTIMATES IN NON-SOLONOX MODE (LOW LOAD)

At operating loads < 50% (<40% load for the *Titan* 250) on natural gas fuel and < 65% (< 80% load for *Centaur* 40) on liquid fuels, *SoLoNOx* engines are controlled to increase stability and transient response capability. The control steps that are required affect emissions in two ways: 1) pilot fuel flow is increased, increasing NOx emissions, and 2) airflow through the combustor is increased, increasing CO emissions. Note that the load levels are approximate. Engine controls are triggered either by power output for single-shaft engines or gas producer speed for two-shaft engines.

A conservative method for estimating emissions of NOx at low loads is to use the applicable NSPS: 40CFR60 subpart GG or KKKK. For projects that commence construction after February 18, 2005, subpart KKKK is the applicable NSPS and contains a NOx level of 150 ppm @ 15% O_2 for operating loads less than 75%.

Table 4 provides estimates of NOx, CO, and UHC emissions when operating in non-SoLoNOx mode for natural gas or liquid fuel. The estimated emissions can be assumed to vary linearly as load is decreased from just below 50% load for natural gas (or 65% load for liquid fuel) to idle.

The estimates in Table 4 apply for any product for gas only or dual fuel systems using pipeline quality natural gas. Refer to Product Information Letter 205 for *Mercury* 50 emissions estimates.

Table 4. Estimated Emissions in non-SoLoNOx Mode

Ambient	Fuel System	Engine Load	NOx, ppm	CO, ppm	UHC, ppm
***Centaur* 40/50, *Taurus* 60/65/70, *Mars* 90/100, *Titan* 130**					
≥ –20°F (–29°C)	Natural Gas	Less than 50%	70	8,000	800
		Idle	50	10,000	1,000
< –20°F (–29°C)	Natural Gas	Less than 50%	120	8,000	800
		Idle	120	10,000	1,000
***Titan* 250**					
≥ –20°F (–29°C)	Natural Gas	Less than 40%	50	25	20
		Idle	50	2,000	200
< –20°F (–29°C)	Natural Gas	Less than 40%	70	150	50
		Idle	70	2,000	200
***Centaur* 50, *Taurus* 60/70, *Mars* 100, *Titan* 130**					
≥ –20°F (–29°C)	Liquid	Less than 65%	120	1,000	100
		Idle	120	10,000	3,000
< –20°F (–29°C)	Liquid	Less than 65%	120	1,000	150
		Idle	120	10,000	3,000
***Centaur* 40**					
≥ –20°F (–29°C)	Liquid	Less than 80%	120	1,000	100
		Idle	120	10,000	3,000
< –20°F (–29°C)	Liquid	Less than 80%	120	1,000	150
		Idle	120	10,000	3,000

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Volatile Organic Compound, Sulfur Dioxide, and Formaldehyde Emission Estimates

Leslie Witherspoon
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PURPOSE

This Product Information Letter summarizes methods that are available to estimate emissions of volatile organic compounds (VOC), sulfur dioxide (SO_2), and formaldehyde from gas turbines. Emissions estimates of these pollutants are often necessary during the air permitting process.

INTRODUCTION

In absence of site-specific or representative source test data, Solar refers customers to a United States Environmental Protection Agency (EPA) document titled "AP-42" or other appropriate EPA reference documents. AP-42 is a collection of emission factors for different emission sources. The emission factors found in AP-42 provide a generally accepted way of estimating emissions when more representative data are not available. The most recent version of AP-42 (dated April 2000) can be found at:

http://www.epa.gov/ttn/chief/ap42/ch03/index.html

Solar does not typically warranty the emission rates for VOC, SO_2 or formaldehyde.

Volatile Organic Compounds

Many permitting agencies require gas turbine users to estimate emissions of VOC, a subpart of the unburned hydrocarbon (UHC) emissions, during the air permitting process. Volatile organic compounds, non-methane hydrocarbons (NMHC), and reactive organic gases (ROG) are some of the many ways of referring to the non-methane (and non-ethane) portion of an "unburned hydrocarbon" emission estimate.

For natural gas fuel, Solar's customers use 10-20% of the UHC emission rate to represent VOC emissions. The estimate of 10-20% is based on a ratio of total non-methane hydrocarbons to total organic compounds. The use of 10-20% provides a conservative estimate of VOC emissions. The balance of the UHC is assumed to be primarily methane.

For liquid fuel, it is appropriate to estimate that 100% of the UHC emission estimate is VOC.

Sulfur Dioxide

Sulfur dioxide emissions are produced by conversion of sulfur in the fuel to SO_2. Since Solar does not control the amount of sulfur in the fuel, we are unable to predict SO_2 emissions without a site fuel composition analysis. Customers generally estimate SO_2 emissions with a mass balance calculation by assuming that any sulfur in the fuel will convert to SO_2. For reference, the typical mass balance equation is shown below.

Variables: wt % of sulfur in fuel
Btu/lb fuel (LHV*)
MMBtu/hr fuel flow (LHV)

$$\frac{\text{lb SO}_2}{\text{hr}} = \left(\frac{\text{wt\% Sulfur}}{100}\right)\left(\frac{\text{lb fuel}}{\text{Btu}}\right)\left(\frac{10^6\ \text{Btu}}{\text{MMBtu}}\right)\left(\frac{\text{MMBtu fuel}}{\text{hr}}\right)\left(\frac{\text{MW SO}_2}{\text{MW Sulfur}}\right)$$

As an alternative to the mass balance calculation, EPA's AP-42 document can be used. AP-42 (Table 3.1-2a, April 2000) suggests emission factors of 0.0034 lb/MMBtu for gas fuel (HHV*) and 0.033 lb/MMBtu for liquid fuel (HHV).

*LHV = Lower Heating Value; HHV = Higher Heating Value

Formaldehyde

In gas turbines, formaldehyde emissions are a result of incomplete combustion. Formaldehyde in the exhaust stream is unstable and very difficult to measure. In addition to turbine characteristics including combustor design, size, maintenance history, and load profile, the formaldehyde emission level is also affected by:

- Ambient temperature
- Humidity
- Atmospheric pressure
- Fuel quality
- Formaldehyde concentration in the ambient air
- Test method measurement variability
- Operational factors

The emission factor data in Table 1 is an excerpt from an EPA memo: "Revised HAP Emission Factors for Stationary Combustion Turbines, 8/22/03." The memo presents hazardous air pollutant (HAP) emission factor data in several categories including: mean, median, maximum, and minimum. The emission factors in the memo are a compilation of the HAP data EPA collected during the Maximum Achievable Control Technology (MACT) standard development process. The emission factor documentation shows there is a high degree of variability in formaldehyde emissions from gas turbines, depending on the manufacturer, rating size of equipment, combustor design, and testing events. To estimate formaldehyde emissions from gas turbines, users should use the emission factor(s) that best represent the gas turbines actual / planned operating profile. Refer to the memo for alternative emission factors.

Table 1. EPA's Total HAP and Formaldehyde Emission Factors for <50 MW Lean-Premix Gas Turbines burning Natural Gas

(Source: Revised HAP Emission Factors for Stationary Combustion Turbines, OAR-2002-0060, IV-B-09, 8/22/03)

Pollutant	Engine Load	95% Upper Confidence of Mean, lb/MMBtu HHV	95% Upper Confidence of Data, lb/MMBtu HHV	Memo Reference
Total HAP	> 90%	0.00144	0.00258	Table 19
Total HAP	All	0.00160	0.00305	Table 16
Formaldehyde	> 90%	0.00127	0.00241	Table 19
Formaldehyde	All	0.00143	0.00288	Table 16

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Emission Estimates at Start-up, Shutdown, and Commissioning for SoLoNOx Combustion Products

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PURPOSE

The purpose of this Product Information Letter (PIL) is to provide emission estimates for start-up and shutdown events for *Solar*® gas turbines with *SoLoNOx*™ dry low emissions combustion systems. The commissioning process is also discussed.

INTRODUCTION

The information presented in this document is representative for both generator set (GS) and compressor set/mechanical drive (CS/MD) combustion turbine applications. Operation of duct burners and/or any add-on control equipment is not accounted for in the emissions estimates. Emissions related to the start-up, shutdown, and commissioning of combustion turbines will not be guaranteed or warranted.

Combustion turbine start-up occurs in one of three modes: cold, warm, or hot. On large, utility size, combustion turbines, the start-up time varies by the "mode". The start-up duration for a hot, warm, or cold *Solar* turbine is less than 10 minutes in simple-cycle and most combined heat and power applications.

Heat recovery steam generator (HRSG) steam pressure is usually 250 psig or less. At 250 psig or less, thermal stress within the HRSG is minimized and, therefore, firing ramp-up is not limited. However, some combined heat and power plant applications will desire or dictate longer start-up times, therefore emissions assuming a 60-minute start are also estimated.

A typical shutdown for a *Solar* turbine is <10 minutes. Emissions estimates for an elongated shutdown, 30-minutes, are also included.

Start-up and shutdown emissions estimates for the *Mercury*™ 50 engine are found in PIL 205.

For start-up and shutdown emissions estimates for conventional combustion turbines, landfill gas, digester gas, or other alternative fuel applications, contact Solar's Environmental Programs Department.

START-UP SEQUENCE

The start-up sequence, or getting to *SoLoNOx* combustion mode, takes three steps:

1. Purge-crank
2. Ignition and acceleration to idle
3. Loading / thermal stabilization

During the "purge-crank" step, rotation of the turbine shaft is accomplished with a starter motor to remove any residual fuel gas in the engine flow path and exhaust. During "ignition and acceleration to idle," fuel is introduced into the combustor and ignited in a diffusion flame mode and the engine rotor is accelerated to idle speed.

The third step consists of applying up to 50% load[1] while allowing the combustion flame to transition and stabilize. Once 50% load is achieved, the turbine transitions to *SoLoNOx* combustion mode and the engine control system begins to hold the combustion primary zone temperature and limit pilot fuel to achieve the targeted nitrogen oxides (NOx), carbon monoxide (CO), and unburned hydrocarbons (UHC) emission levels.

Steps 2 and 3 are short-term transient conditions making up less than 10 minutes.

SHUTDOWN PROCESS

Normal, planned cool down/shutdown duration varies by engine model. The *Centaur*® 40, *Centaur* 50, *Taurus*™ 60, and *Taurus* 65 engines take about 5 minutes. The *Taurus* 70, *Mars*® 90 and 100, *Titan*™ 130 and *Titan* 250 engines take about 10 minutes. Typically, once the shutdown process starts, the emissions will remain in *SoLoNOx* mode for approximately 90 seconds and move into a transitional mode for the balance of the estimated shutdown time (assuming the unit was operating at full-load).

START-UP AND SHUTDOWN EMISSIONS ESTIMATES

Tables 1 through 5 summarize the estimated pounds of emissions per start-up and shutdown event for each product. Emissions estimates are presented for both GS and CS/MD applications on both natural gas and liquid fuel (diesel #2). The emissions estimates are calculated using empirical exhaust characteristics.

COMMISSIONING EMISSIONS

Commissioning generally takes place over a two-week period. Static testing, where no combustion occurs, usually requires one week and no emissions are expected. Dynamic testing, where combustion will occur, will see the engine start and shutdown a number of times and a variety of loads will be placed on the system. It is impossible to predict how long the turbine will run and in what combustion / emissions mode it will be running. The dynamic testing period is generally followed by one to two days of "tune-up" during which the turbine is running at various loads, most likely within low emissions mode (warranted emissions range).

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[1] 40% load for the *Titan* 250 engine on natural gas. 65% load for all engines on liquid fuel (except 80% load for the *Centaur* 40).

Table 1. ***Estimation of Start-up and Shutdown Emissions (lbs/event) for SoLoNOx Generator Set Applications***
10 Minute Start-up and 10 Minute Shutdown
Natural Gas Fuel

Data will NOT be warranted under any circumstances

	Centaur 40 4701S				Centaur 50 6201S				Taurus 60 7901S				Taurus 65 8401S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	0.6	58.1	3.3	359	0.8	75.0	4.3	454	0.8	78.5	4.5	482	0.9	85.8	4.9	523
Total Emissions per Shutdown (lbs)	0.3	25.5	1.5	160	0.4	31.1	1.8	194	0.4	34.7	2.0	217	0.4	38.2	2.2	237

	Taurus 70 10801S				Mars 90 13002S GSC				Mars 100 16002S GSC				Titan 130 20501S				Titan 250 30002S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	1.1	103.9	5.9	634	1.4	129.0	7.4	868	1.6	151.2	8.6	952	2.1	195.6	11.2	1,194	2.5	22.7	1.5	1,925
Total Emissions per Shutdown (lbs)	1.3	110.7	6.3	689	1.7	147.9	8.4	912	1.9	166.8	9.5	1,026	2.4	210.0	12.0	1,303	3.0	19.9	1.5	1,993

Assumes ISO conditions: 59F, 60% RH, sea level, no losses

Assumes unit is operating at full load prior to shutdown.

Assumes natural gas fuel; ES 9-98 compliant.

Table 2. Estimation of Start-up and Shutdown Emissions (lbs/event) for SoLoNOx Generator Set Applications
60 Minute Start-up and 30 Minute Shutdown
Natural Gas Fuel

Data will NOT be warranted under any circumstances

	Centaur 40 4701S				Centaur 50 6201S				Taurus 60 7901S				Taurus 65 8401S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	4.1	219.4	13.0	3,420	5.0	272.4	16.1	4,219	5.7	299.8	17.8	4,780	6.1	326.5	19.3	5,074
Total Emissions per Shutdown (lbs)	1.8	121.1	7.1	1,442	2.3	163.3	9.5	1,834	2.5	163.5	9.6	1,994	2.6	177.2	10.4	2,119

	Taurus 70 10801S				Mars 90 13002S				Mars 100 16002S				Titan 130 20501S				Titan 250 30002S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	7.6	410.3	24.2	6,164	10.5	570.8	33.7	8,641	11.3	583.5	34.6	9,691	13.8	740.4	43.8	11,495	14.6	75.5	7.3	16,253
Total Emissions per Shutdown (lbs)	3.3	223.0	13.0	2,588	4.3	277.0	16.2	3,685	4.8	308.1	18.0	4,056	6.0	405.3	23.7	4,826	6.2	52.6	4.1	7,222

Assumes ISO conditions: 59F, 60% RH, sea level, no losses.

Assumes unit is operating at full load prior to shutdown.

Assumes natural gas fuel; ES 9-98 compliant.

Table 3. Estimation of Start-up and Shutdown Emissions (lbs/event) for SoLoNOx CS/MD Applications
10 Minute Start-up and 10 Minute Shutdown
Natural Gas Fuel

Data will NOT be warranted under any circumstances

	Centaur 40 4702S				Centaur 50 6102S				Taurus 60 7802S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	0.7	64.4	3.7	392	0.8	69.1	4.0	469	0.7	64.3	3.7	410
Total Emissions per Shutdown (lbs)	0.3	30.2	1.7	181	0.4	35.4	2.0	217	0.4	33.0	1.9	204

	Taurus 70 10302S				Mars 90 13002S CSMD				Mars 100 16002S CSMD				Titan 130 20502S				Titan 250 30002S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	0.8	73.1	4.2	519	1.2	109.3	6.2	805	1.4	123.5	7.1	829	1.9	176.9	10.1	1,161	2.6	26.2	1.7	1,794
Total Emissions per Shutdown (lbs)	1.1	93.4	5.3	575	1.5	132.6	7.6	817	1.7	149.2	8.5	920	2.4	207.6	11.9	1,272	2.9	19.1	1.4	1,918

Assumes ISO conditions: 59F, 60% RH, sea level, no losses.

Assumes unit is operating at full load prior to shutdown.

Assumes natural gas fuel; ES 9-98 compliant.

Table 4. Estimation of Start-up and Shutdown Emissions (lbs/event) for SoLoNOx Generator Set
10 Minute Start-up and 10 Minute Shutdown
Liquid Fuel (Diesel #2)

Data will NOT be warranted under any circumstances

	Centaur 40 4701S				Centaur 50 6201S				Taurus 60 7901S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	1.3	44.5	7.4	473	1.7	59.0	9.8	601	1.7	59.8	9.9	636
Total Emissions per Shutdown (lbs)	0.6	17.3	2.8	211	0.7	21.2	3.4	256	0.8	23.5	3.8	286

	Taurus 70 10801S				Mars 100 16002S GSC				Titan 130 20501S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	2.3	78.5	13.0	823	3.4	114.1	18.8	1,239	4.3	147.5	24.4	1,547
Total Emissions per Shutdown (lbs)	2.5	73.6	12.0	889	3.8	111.4	18.1	1,331	4.7	139.1	22.6	1,677

Assumes ISO conditions: 59F, 60% RH, sea level, no losses.

Assumes unit is operating at full load prior to shutdown.

Assumes #2 Diesel fuel; ES 9-98 compliant.

Table 5. Estimation of Start-up and Shutdown Emissions (lbs/event) for SoLoNOx Generator Set
60 Minute Start-up and 30 Minute Shutdown
Liquid Fuel (Diesel #2)

Data will NOT be warranted under any circumstances

	Centaur 40 4701S				Centaur 50 6201S				Taurus 60 7901S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	11.7	194.7	30.9	4,255	15.2	271.9	43.3	5,302	14.7	282.6	45.0	5,962
Total Emissions per Shutdown (lbs)	4.4	84.7	13.6	1,816	6.7	164.3	27.0	2,334	6.3	159.0	26.0	2,515

	Taurus 70 10801S				Mars 100 16002S				Titan 130 20501S			
	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)	NOx (lbs)	CO (lbs)	UHC (lbs)	CO2 (lbs)
Total Emissions per Start (lbs)	18.4	360.3	57.4	7,375	29.1	552.0	87.7	11,685	34.4	677.0	108.0	13,731
Total Emissions per Shutdown (lbs)	8.0	207.8	34.1	3,156	12.3	302.6	49.4	4,970	15.0	388.5	63.7	5,876

Assumes ISO conditions: 59F, 60% RH, sea level, no losses.

Assumes unit is operating at full load prior to shutdown.

Assumes #2 Diesel fuel; ES 9-98 compliant.

SCR CATALYST DESIGN DATASHEET

ENQUIRY DETAILS	
Enquiry Number	32237
Revision	0
Date of Revision	28-May-2015
Project Name	Atlantic Coast Pipeline
Project Location	Buckingham
Application	Simple Cycle
Number of SCRs	17

PROCESS DATA														
Design Case			Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12
Customer Design Case			Centaur 40	Centaur 40	Centaur 50L	Centaur 50L	Taurus 60	Taurus 60	Taurus 70	Taurus 70	Mars 100	Mars 100	Titan 130	Titan 130
Percent Load		Percent	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Fuel Case		Percent	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
EXHAUST GAS EMISSIONS DATA (BEFORE COOLING)														
Exhaust Gas Mass Flowrate, Wet		lb/h	164994	127403	161184	127484	186880	151704	247255	179824	367228	289445	437956	341226
Exhaust Gas Volumetric Flowrate, Wet		ACFM	87269	73508	91761	80971	107807	96052	139492	112383	207193	177388	254955	215260
Exhaust Gas Temperature		degrees F	779.0	873.0	871.0	1004.0	888.0	999.0	858.0	980.0	859.0	953.0	900.0	993.0
Exhaust Gas Composition														
Component	*MW*													
O2	31.999	vol% (wet)	15.78	15.29	14.80	14.08	14.50	13.93	14.39	13.88	14.73	14.23	14.40	13.69
H2O	18.015	vol% (wet)	4.67	8.15	5.55	9.21	5.81	9.34	5.91	9.39	5.61	9.08	5.90	9.55
N2	28.013	vol% (wet)	76.23	73.41	75.88	73.01	75.78	72.96	75.74	72.93	75.85	73.06	75.75	72.88
CO2	44.010	vol% (wet)	2.41	2.27	2.86	2.83	3.00	2.90	3.05	2.93	2.90	2.76	3.04	3.01
Ar	39.948	vol% (wet)	0.91	0.88	0.91	0.87	0.91	0.87	0.91	0.87	0.91	0.87	0.91	0.87
			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Emissions from the Source	@ %O2	15												
Reference applicable for ppmvd and mg/Nm3 (dry)														
Nox as NO2		ppmvd	25.00	25.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
Nox as NO2		lb/h	4.66	3.44	1.95	1.55	2.38	1.89	3.20	2.26	4.51	3.44	5.66	4.43
CO		ppmvd	50.00	50.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
CO		lb/h	5.67	4.19	3.31	2.63	4.02	3.20	5.42	3.83	7.62	5.81	9.58	7.49
SO2		ppmvd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO2		lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO3		ppmvd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO3		lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
COOLING AIR DATA														
Cooling Air Mass Flowrate, Wet		lb/h	7181.2	27800.1	29270.9	57444.9	38705.3	67013.0	40077.2	73373.3	60074.6	104237.6	98583.9	147099.4
Cooling Air Volumetric Flowrate, Wet		ACFM	1387	6438	5653	13303	7475	15518	7739	16991	11601	24139	19040	34064
Ambient Air Temperature		degrees F	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00
Relative Humidity		Percent	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
EXHAUST GAS EMISSIONS DATA (AFTER COOLING)														
Exhaust Gas Mass Flowrate, Wet		lb/h	172175	155203	190455	184929	225585	218717	287332	253197	427303	393683	536550	488325
Exhaust Gas Volumetric Flowrate, Wet		ACFM	88898	80938	98384	96292	116559	113920	148553	131945	220785	205195	277243	254464
Exhaust Gas Temperature (after cooling)		degrees F	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00
Exhaust Gas Composition														
Component	*MW*													
O2	31.999	vol% (wet)	15.99	16.15	15.73	15.95	15.59	15.82	15.29	15.68	15.59	15.78	15.59	15.62
H2O	18.015	vol% (wet)	4.48	7.38	4.72	7.55	4.84	7.67	5.11	7.79	4.84	7.70	4.84	7.84
N2	28.013	vol% (wet)	76.30	73.71	76.21	73.65	76.16	73.61	76.05	73.56	76.15	73.59	76.16	73.54
CO2	44.010	vol% (wet)	2.31	1.87	2.43	1.97	2.50	2.03	2.63	2.10	2.50	2.04	2.49	2.12
Ar	39.948	vol% (wet)	0.91	0.88	0.91	0.88	0.91	0.88	0.91	0.88	0.91	0.88	0.91	0.88
			100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Emissions from the Source	@ %O2	15												
Reference applicable for ppmvd and mg/Nm3 (dry)														
Nox as NO2		ppmvd	25.00	25.06	9.00	9.04	9.00	9.04	9.00	9.04	9.00	9.03	9.00	9.04
Nox as NO2		lb/h	4.66	3.44	1.95	1.55	2.38	1.89	3.20	2.26	4.51	3.44	5.66	4.43
CO		ppmvd	50.00	50.13	25.00	25.11	25.00	25.11	25.00	25.10	25.00	25.09	25.00	25.11
CO		lb/h	5.67	4.19	3.31	2.63	4.02	3.20	5.42	3.83	7.62	5.81	9.58	7.49
SO2		ppmvd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO2		lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO3		ppmvd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO3		lb/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Particulates		kg/h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trace Elements		mg/Nm3 (dry)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VOC		ppmvd	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Amount of Nox as NO2		Percent	50	50	50	50	50	50	50	50	50	50	50	50
Nox Reduction		Percent	80.00	80.00	44.44	44.44	44.44	44.44	44.44	44.44	44.44	44.44	44.44	44.44
Dilution Air Required		lb/h	327	327	327	327	327	327	327	327	327	327	327	327
Dilution Air Required		SCFM	68	68	68	68	68	68	68	68	68	68	68	68
Aqueous Ammonia Requirement		lb/h	11	8	6	5	7	6	10	7	14	10	17	13
Aqueous Ammonia Requirement		gal/month	1046	772	569	452	692	551	932	659	1311	1000	1648	1289
Total Mass injected by SCR		lb/h	338	335	333	332	334	333	337	334	341	337	344	340
Exhaust Gas Mass Flowrate, Wet at SCR catalyst		lb/h	172513.1	155538.2	190787.8	185260.6	225919.5	219049.7	287668.9	253531.1	427643.2	394020.0	536894.1	488665.8
Exhaust Gas Vol Flowrate, Wet at SCR Catalyst		ACFM	89073	81113	98556	96465	116732	114093	148727	132119	220962	205371	277421	254642
Performance Warranties	@ %O2	15												
Reference applicable for ppmvd and mg/Nm3 (dry)														
Nox as NO2		ppmvd	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Nox as NO2		lb/h	0.93	0.69	1.09	0.86	1.32	1.05	1.78	1.26	2.50	1.91	3.15	2.46
NH3 Slip		ppmvd	10.00	10.03	10.00	10.04	10.00	10.04	10.00	10.04	10.00	10.04	10.00	10.04
NH3 Slip		lb/h	0.69	0.51	0.80	0.64	0.98	0.78	1.32	0.93	1.85	1.41	2.33	1.82
AFCU Selected			AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15	AQEL15
SO2 to SO3 Conversion		Percent	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA
Pressure Drop across the catalyst		inH2O	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA	VTA

** VTA = Vendor to Advise*

SITE/AMBIENT CONDITIONS		
Design Ambient Temperature	100	degrees F
Design Ambient Pressure	407	inH2O
Site Elevation	1500	ft
Gauge Duct Pressure	20.00	inH2O
Relative Humidity	60	Percent

AFCU DESIGN		
Reagent	Aqueous Ammonia	
Reagent Concentration	19.00	%w/w

ENGINEERING TECHNOLOGY INCORPORATED

COMBUSTION ANALYSIS

CLIENT:	Dominion
PLANT/PROJECT:	GreensvilleR2
REFERENCE:	WB HTR
DATE	15-Jun-15

PROGRAM: Combustion Analysis Version 1.03

FUEL GAS ANALYSIS

SUBSTANCE/FORM.	Mol %
NITROGEN, N2	0.994
CAR DIOXIDE, CO2	1.041
METHANE, CH4	94.206
ETHANE, C2H6	2.923
PROPANE, C3H8	0.546
n-BUTANE, C4H10	0.084
ISOBUTANE, C4H10	0.079
n-PENTANE, C5H12	0.022
ISOPENTANE, C5H12	0.024
n-HEXANE,C6H14	0.032
n-HEPTANE,C7H16	0.049
TOTAL	100.000

HEAT TRANSFER	11.250	MM BTU/HR				
GROSS EFF.	70.000	% HHV	77.57	%LHV		
EXCESS AIR	15.000	%	2.98	% O2 DRY	2.490	% O2 WET
NUMBER OF STACKS	3.000					
STACK I.D.	23.250	IN				
STACK TEMP	897.000	DEG F				
STACK VELOCITY	15.733	FT/SEC				
MMBTU/HR REL =	16.071	GROSS	MMBTU/HR REL =	14.504	NET	

FLUE GAS (ESTIMATED VALUES)

	WET	DRY	CO2	H2O	N2	O2	SO2
					COMPOSITION		
M.W. =	27.852	29.78					
SCFM =	3195.260	2670.51	271.05	524.753	2319.902	79.55	0.00
LB/HR =	14070.097	12574.22	1887.49	1495.877	10283.920	402.81	0.00

	NOx	CO	VOC(NM)	PM10
PPMV (D,TRUE)=	9.000	50.00	7.00	
LB/HR =	0.175	0.592	0.104	0.120
LB/MM BTU (HHV) =	0.011	0.037	0.006	0.007
LB/MM BTU (LHV) =	0.012	0.041	0.007	0.008

COMBUSTION AIR REQUIRED

2919	SCFM	11.20	SCF/SCF FUEL
13373	#/HR		

FUEL GAS

15634	SCFH	17.17	M.W.	1028.450	BTU/FT3 (HHV)
708	#/HR	0.59	S.G.	928.122	BTU/FT3 (LHV)

STACK HEIGHT FROM GRADE Approx 22'-10"

[signature]
15/JUN/2015

ENGINEERING TECHNOLOGY INCORPORATED

COMBUSTION ANALYSIS

CLIENT:	Dominion
PLANT/PROJECT:	Brunswick R1
REFERENCE:	WB HTR
DATE	15-Jun-15

PROGRAM: Combustion Analysis Version 1.03

FUEL GAS ANALYSIS

SUBSTANCE/FORM.	Mol %
NITROGEN, N2	0.994
CAR DIOXIDE, CO2	1.041
METHANE, CH4	94.206
ETHANE, C2H6	2.923
PROPANE, C3H8	0.546
n-BUTANE, C4H10	0.084
ISOBUTANE, C4H10	0.079
n-PENTANE, C5H12	0.022
ISOPENTANE, C5H12	0.024
n-HEXANE,C6H14	0.032
n-HEPTANE,C7H16	0.049
TOTAL	100.000

HEAT TRANSFER	10.500	MM BTU/HR				
GROSS EFF.	70.000	% HHV		77.57	%LHV	
EXCESS AIR	15.000	%		2.98	% O2 DRY	2.490 % O2 WET
NUMBER OF STACKS	3.000					
STACK I.D.	23.500	IN				
STACK TEMP	897.000	DEG F				
STACK VELOCITY	14.374	FT/SEC				
MMBTU/HR REL =	15.000	GROSS	MMBTU/HR REL =	13.537		NET

FLUE GAS (ESTIMATED VALUES)

	WET	DRY	CO2	H2O	N2	O2	SO2
					COMPOSITION		
M.W. =	27.852	29.78					
SCFM =	2982.243	2492.47	252.98	489.769	2165.242	74.25	0.00
LB/HR =	13132.090	11735.94	1761.66	1396.152	9598.325	375.95	0.00

	NOx	CO	VOC(NM)	PM10
PPMV (D,TRUE)=	9.000	50.00	7.00	
LB/HR =	0.163	0.553	0.097	0.112
LB/MM BTU (HHV) =	0.011	0.037	0.006	0.007
LB/MM BTU (LHV) =	0.012	0.041	0.007	0.008

COMBUSTION AIR REQUIRED

2724	SCFM	11.20	SCF/SCF FUEL
12482	#/HR		

FUEL GAS

14591	SCFH	17.17	M.W.	1028.450	BTU/FT3 (HHV)
661	#/HR	0.59	S.G.	928.122	BTU/FT3 (LHV)

STACK HEIGHT FROM GRADE
Approx 22'-16"

[signature]
15/JUN/2015

Capstone

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Technical Reference

Capstone MicroTurbine™ Systems Emissions

Summary

Capstone MicroTurbine™ systems are inherently clean and can meet some of the strictest emissions standards in the world. This technical reference is to provide customers with information that may be requested by local air permitting organizations or to compare air quality impacts of different technologies for a specific project. The preferred units of measure are "output based"; meaning that the quantity of a particular exhaust emission is reported relative to the useable output of the microturbine – typically in pounds per megawatt hour for electrical generating equipment. This technical reference also provides volumetric measurements in parts per million and milligrams per normal cubic meter. A conversion between several common units is also provided.

Maximum Exhaust Emissions at ISO Conditions

Table 1 below summarizes the exhaust emissions at full power and ISO conditions for different Capstone microturbine models. Note that the fuel can have a significant impact on certain emissions. For example landfill and digester gas can be made up of a wide variety of fuel elements and impurities, and typically contains some percentage of carbon dioxide (CO_2). This CO_2 dilutes the fuel, makes complete combustion more difficult, and results in higher carbon monoxide emissions (CO) than for pipeline-quality natural gas.

Table 1. Emission for Different Capstone Microturbine Models in [lb/MWhe]

Model	Fuel	NOx	CO	VOC (5)
C30 NG	Natural Gas (1)	0.64	1.8	0.23
CR30 MBTU	Landfill Gas (2)	0.64	22.0	1.00
CR30 MBTU	Digester Gas (3)	0.64	11.0	1.00
C30 Liquid	Diesel #2 (4)	2.60	0.41	0.23
C65 NG Standard	Natural Gas (1)	0.46	1.25	0.10
C65 NG Low NOx	Natural Gas (1)	0.17	1.30	0.10
C65 NG CARB	Natural Gas (1)	0.17	0.24	0.05
CR65 Landfill	Landfill Gas (2)	0.46	4.0	0.10
CR65 Digester	Digester Gas (3)	0.46	4.0	0.10
C200 NG	Natural Gas (1)	0.40	1.10	0.10
C200 NG CARB	Natural Gas (1)	0.14	0.20	0.04
CR200 Digester	Digester Gas (3)	0.40	3.6	0.10

Notes:

(1) Emissions for standard natural gas at 1,000 BTU/scf (HHV) or 39.4 MJ/m3 (HHV)

(2) Emissions for surrogate gas containing 42% natural gas, 39% CO2, and 19% Nitrogen

(3) Emissions for surrogate gas containing 63% natural gas and 37% CO2

(4) Emissions for Diesel #2 according to ASTM D975-07b

(5) Expressed as Methane

Table 2 provides the same output-based information shown in Table 1, but expressed in grams per horsepower hour (g/hp-hr).

Table 2. Emission for Different Capstone Microturbine Models in [g/hp-hr]

Model	Fuel	NOx	CO	VOC (5)
C30 NG	Natural Gas (1)	0.22	0.60	0.078
CR30 MBTU	Landfill Gas (2)	0.22	7.4	0.340
CR30 MBTU	Digester Gas (3)	0.22	3.7	0.340
C30 Liquid	Diesel #2 (4)	0.90	0.14	0.078
C65 NG Standard	Natural Gas (1)	0.16	0.42	0.034
C65 NG Low NOx	Natural Gas (1)	0.06	0.44	0.034
C65 NG CARB	Natural Gas (1)	0.06	0.08	0.017
CR65 Landfill	Landfill Gas (2)	0.16	1.4	0.034
CR65 Digester	Digester Gas (3)	0.16	1.4	0.034
C200 NG	Natural Gas (1)	0.14	0.37	0.034
C200 NG CARB	Natural Gas (1)	0.05	0.07	0.014
CR200 Digester	Digester Gas (3)	0.14	1.3	0.034

Notes: - same as for Table 1

Emissions may also be reported on a volumetric basis, with the most common unit of measurement being parts per million. This is typically a measurement that is corrected to specific oxygen content in the exhaust and without considering moisture content. The abbreviation for this unit of measurement is "ppmvd" (parts per million by volume, dry) and is corrected to 15% oxygen for electrical generating equipment such as microturbines. The relationship between an output based measurement like pounds per MWh and a volumetric measurement like ppmvd depends on the characteristics of the generating equipment and the molecular weight of the criteria pollutant being measured. Table 3 expresses the emissions in ppmvd at 15% oxygen for the Capstone microturbine models shown in Table 1. Note that raw measurements expressed in ppmv will typically be lower than the corrected values shown in Table 3 because the microturbine exhaust has greater than 15% oxygen.

Another volumetric unit of measurement expresses the mass of a specific criteria pollutant per standard unit of volume. Table 4 expresses the emissions in milligrams per normal cubic meter at 15% oxygen. Normal conditions for this purpose are expresses as one atmosphere of pressure and zero degrees Celsius. Note that both the ppmvd and mg/m3 measurements are for specific oxygen content. A conversion can be made to adjust either unit of measurement to other reference oxygen contents, if required. Use the equation below to convert from one reference oxygen content to another:

$$\text{Emissions at New } O_2 = \frac{(20.9 - \text{New } O_2 \text{ Percent})}{(20.9 - \text{Current } O_2 \text{ Percent})} \times \text{Emissions at Current } O_2$$

For example, to express 9 ppmvd of NOx at 15% oxygen to ppmvd at 3% oxygen:

$$\text{Emissions at 3\% } O_2 = \frac{(20.9 - 3.0)}{(20.9 - 15.0)} \times 9 = 27 \text{ ppmvd}$$

Table 3. Emission for Different Capstone Microturbine Models in [ppmvd] at 15% O_2

Model	Fuel	NOx	CO	VOC
C30 NG	Natural Gas (1)	9	40	9
CR30 MBTU	Landfill Gas (2)	9	500	40
CR30 MBTU	Digester Gas (3)	9	250	40
C30 Liquid	Diesel #2 (4)	35	9	9
C65 NG Standard	Natural Gas (1)	9	40	7
C65 NG Low NOx	Natural Gas (1)	4	40	7
C65 NG CARB	Natural Gas (1)	4	8	3
CR65 Landfill	Landfill Gas (2)	9	130	7
CR65 Digester	Digester Gas (3)	9	130	7
C200 NG	Natural Gas (1)	9	40	7
C200 NG CARB	Natural Gas (1)	4	8	3
CR200 Digester	Digester Gas (3)	9	130	7

Notes: same as Table 1

Table 4. Emission for Different Capstone Microturbine Models in [mg/m3] at 15% O_2

Model	Fuel	NOx	CO	VOC (5)
C30 NG	Natural Gas (1)	18	50	6
CR30 MBTU	Landfill Gas (2)	18	620	30
CR30 MBTU	Digester Gas (3)	18	310	30
C30 Liquid	Diesel #2 (4)	72	11	6
C65 NG Standard	Natural Gas (1)	19	50	5
C65 NG Low NOx	Natural Gas (1)	8	50	5
C65 NG CARB	Natural Gas (1)	8	9	2
CR65 Landfill	Landfill Gas (2)	18	160	5
CR65 Digester	Digester Gas (3)	18	160	5
C200 NG	Natural Gas (1)	18	50	5
C200 NG CARB	Natural Gas (1)	8	9	2
CR200 Digester	Digester Gas (3)	18	160	5

Notes: same as Table 1

The emissions stated in Tables 1, 2, 3 and 4 are guaranteed by Capstone for new microturbines during the standard warranty period. They are also the expected emissions for a properly maintained microturbine according to manufacturer's published maintenance schedule for the useful life of the equipment.

Emissions at Full Power but Not at ISO Conditions

The maximum emissions in Tables 1, 2, 3 and 4 are at full power under ISO conditions. These levels are also the expected values at full power operation over the published allowable ambient temperature and elevation ranges.

Emissions at Part Power

Capstone microturbines are designed to maintain combustion stability and low emissions over a wide operating range. Capstone microturbines utilize multiple fuel injectors, which are switched on or off depending on the power output of the turbine. All injectors are typically on when maximum power is demanded, regardless of the ambient temperature or elevation. As the load requirements of the microturbine are decreased, injectors will be switched off to maintain stability and low emissions. However, the emissions relative to the lower power output may increase. This effect differs for each microturbine model.

Emissions Calculations for Permitting

Air Permitting agencies are normally concerned with the maximum amount of a given pollutant being emitted per unit of time (for example pounds per day of NOx). The simplest way to make this calculation is to use the maximum microturbine full electrical power output (expressed in MW) multiplied by the emissions rate in pounds per MWhe times the number of hours per day. For example, the C65 CARB microturbine operating on natural gas would have a NOx emissions rate of:

NOx = .17 X (65/1000) X 24 = .27 pounds per day

This would be representative of operating the equipment full time, 24 hours per day, at full power output of 65 kWe.

As a general rule, if local permitting is required, use the published agency levels as the stated emissions for the permit and make sure that this permitted level is above the calculated values in this technical reference.

Consideration of Useful Thermal Output

Capstone microturbines are often deployed where their clean exhaust can be used to provide heating or cooling, either directly or using hot water or other heat transfer fluids. In this case, the local permitting or standards agencies will usually consider the emissions from traditional heating sources as being displaced by the useful thermal output of the microturbine exhaust energy. This increases the useful output of the microturbine, and decreases the relative emissions of the combined heat and power system. For example, the CARB version C65 ICHP system with integral heat recovery can achieve a total system efficiency of 70% or more, depending on inlet water temperatures and other installation-specific characteristics. The electric efficiency of the CARB version C65 microturbine is 28% at ISO conditions. This means that the total NOx output based emissions, including the captured thermal value, is the electric-only emissions times the ratio of electric efficiency divided by total system efficiency:

NOx = .17 X 28/70 = .068 pounds per MWh (based on total system output)

This is typically much less than the emissions that would result from providing electric power using traditional central power plants, plus the emissions from a local hot water heater or boiler. In fact microturbine emissions are so low compared with traditional hot water heaters that installing a Capstone microturbine with heat recovery can actually decrease the local emissions of NOx and other criteria pollutants, without even considering the elimination of emissions from a remote power plant.

Greenhouse Gas Emissions

Many gasses are considered "greenhouse gasses", and agencies have ranked them based on their global warming potential (GWP) in the atmosphere compared with carbon dioxide (CO_2), as well as their ability to maintain this effect over time. For example, methane is a greenhouse gas with a GWP of 21. Criteria pollutants like NOx and organic compounds like methane are monitored by local air permitting authorities, and are subject to strong emissions controls. Even though some of these criteria pollutants can be more troublesome for global warming than CO_2, they are released in small quantities – especially from Capstone microturbines. So the major contributor of concern is carbon dioxide, or CO_2. Emission of CO_2 depends on two things:

1. Carbon content in the fuel
2. Efficiency of converting fuel to useful energy

It is for these reasons that many local authorities are focused on using clean fuels (for example natural gas compared with diesel fuel), achieving high efficiency using combined heat and power systems, and displacing emissions from traditional power plants using renewable fuels like waste landfill and digester gasses.

Table 5 shows the typical CO_2 emissions due to combustion for different Capstone microturbine models at full power and ISO conditions. The values do not include CO_2 that may already exist in the fuel itself, which is typical for renewable fuels like landfill and digester gas. These values are expressed on an output basis, as is done for criteria pollutants in Table 1. The table shows the pounds per megawatt hour based on electric power output only, as well as considering total useful output in a CHP system with total 70% efficiency (LHV). As for criteria pollutants, the relative quantity of CO_2 released is substantially less when useful thermal output is also considered in the measurement.

Table 5. CO_2 Emission for Capstone Microturbine Models in [lb/MWh]

Model	Fuel	CO_2	
		Electric Only	70% Total CHP
C30 NG	Natural Gas (1)	1,690	625
CR30 MBTU	Landfill Gas (1)	1,690	625
CR30 MBTU	Digester Gas (1)	1,690	625
C30 Liquid	Diesel #2 (2)	2,400	855
C65 NG Standard	Natural Gas (1)	1,520	625
C65 NG Low NOx	Natural Gas (1)	1,570	625
C65 NG CARB	Natural Gas (1)	1,570	625
CR65 Landfill	Landfill Gas (1)	1,520	625
CR65 Digester	Digester Gas (1)	1,520	625
C200 NG	Natural Gas (1)	1,330	625
C200 NG CARB	Natural Gas (1)	1,330	625
CR200 Digester	Digester Gas (1)	1,330	625

Notes:

(1) Emissions due to combustion, assuming natural gas with CO_2 content of 117 lb/MMBTU (HHV)

(2) Emissions due to combustion, assuming diesel fuel with CO_2 content of 160 lb/MMBTU (HHV)

Useful Conversions

The conversions shown in Table 6 can be used to obtain other units of emissions outputs. These are approximate conversions.

Table 6. Useful Unit Conversions

From	Multiply By	To Get
lb/MWh	0.338	g/bhp-hr
g/bhp-hr	2.96	lb/MWh
lb	0.454	kg
kg	2.20	lb
kg	1,000	g
hp (electric)	.746	kW
kW	1.34	hp (electric)
MW	1,000	kW
kW	0.001	MW

Definitions

- ISO conditions are defined as: 15 °C (59 °F), 60% relative humidity, and sea level pressure of 101.3 kPa (14.696 psia).
- HHV: Higher Heating Value
- LHV: Lower Heating Value
- kW_{th}: Kilowatt (thermal)
- kW_e : Kilowatt (electric)
- MWh: Megawatt-hour
- hp-hr: horsepower-hour (sometimes referred to as "electric horsepower-hour")
- Scf: Standard cubic foot (standard references ISO temperature and pressure)
- m3: Normal cubic meter (normal references 0 °C and one atmosphere pressure)

Capstone Contact Information

If questions arise regarding this technical reference, please contact Capstone Turbine Corporation for assistance and information:

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